CITIES IN THE SAHARA:
SPATIAL STRUCTURE AND GENERATIVE PROCESSES

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To the memory of my uncle
"Houari Boumedienne"
the late President of Algeria

ABSTRACT

The present thesis examines some aspects of the structure of urban space found in particular towns in the Sahara, and the peculiarities in their dual organisation of the circulation systems: the streets and the roof terraces of the houses inter-connected by another system of walkways, which are exclusively reserved for the circulation of women across the settlements or parts of the settlements. The terrace morphology is developed in different forms and at various degrees of elaboration in these urban systems, which are usually seen as the result of some external determinant factor, such as religion, with the public being wholly male and women confined to the domestic sphere. Since there are no differences in religious terms between these systems, this view cannot be adopted to account for the pronounced differences in their spatial configurations.

The study argues that: i- the terrace morphology is only one instance of the spatial mechanisms which enter in the separation and integration of the sexes, the global organisation of the street system is another; ii- these mechanisms, to include the terrace system, are intimately bound up with the nature of the urban fabric of these towns, which can be characterized as poorly connected and highly segregated, with a distinctive organisation of the main streets with regard to the settlement as a whole. The dense fabric of these towns with large urban blocks creates both, the high level of segregation of the street system and larger roof surfaces; iii- both, the nature of the urban fabric and the global organisation of these systems are strongly related to the generative processes of urban formation, and the underlying rules followed in the aggregation of buildings on the ground. These rules are seen as expressions to social restrictions on relations between and within male and female groups. The computer simulations of the urban growth show that the highly segregated nature of the spatial fabric and its distinctive global organisation are the by-product of a more localized process of building aggregation. The study concludes that the dualistic structure of these towns and its variation lies in the greater emphasis on male-female relations and the greater localization in the structuring of space. It demonstrates then that the relation between the terrace morphology and the urban form of these towns is shown to exist at the deepest level of space organisation, at the level of the generative rules of settlement formation. By this, the study uses an architectural approach to broach the question of relationship between the social and spatial aspects of these towns.

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INTRODUCTION:

The present thesis is concerned with an investigation into the towns of the Mzab region of Southern Algeria, and Ghadames, a saharan oasis in South-western Libya. This concern has been prompted by the existence of a particular morphological feature, "the terrace system", which consists of the rooftops of houses interconnected to one another to form an exclusive domain, used by women for their circulation across the settlement or parts of the settlement. The terrace system seems to allow the women freedom of movement and opportunities to meet each other, without contravening the separation of the sexes which appears to be a main organisational principle in these societies.

Recent studies of the physical and social structure of these towns in particular and of the towns in the Arab world in general, have exploded the myth of the single Arab city type, in which the public sphere is seen as wholly male and women kept out of sight in confinement to the domestic sphere (i.e., Duveyrier H., 1864, p. 257; Gulick J., 1963, pp. 179-198; Delaval B., 1974, p. 254; Wheatly P., 1976, pp. 335-359; Raymond A., 1985, p. 172). The significance of this abstraction implies an enormous importance of Islam as a framework for understanding spatial structures. These studies have therefore concentrated chiefly on the separation of the living space into male and female spheres, seen mainly as the result of religion.

But other studies of a more descriptive character, suggest a certain variation in the way in which the urban space is structured to separate or integrate the sexes (i.e., Donnadieu and Didillon, 1977, p. 69). For example, Etherton comments that

> "in the Arab world, the courtyard house ensures that women may be seen only by their husbands and children... Most courtyards are interconnected so that women can pass from one to another without having to walk in the streets. Where there is more than one storey, these connections often cross the streets transforming the ksar [the town] into a private upper level town for women, and a lower-level commercial town for the men." (Etherton D., 1971, p. 174).

The puzzle then is that the terrace system is developed to a high degree in some settlements and hardly at all in others, while in one case there are substantial differences from one part of the town to the other. The very fact that within the same geographical, social and religious context, the terrace morphology exists in different forms and at different degrees of elaboration, already raises doubts about the way in which these spatial systems have been interpreted, as being wholly the result of some external determinant factor, the religion (i.e., Delaval B., 1974, pp. 253-). Since there do not seem to be substantial differences between these towns in terms of religion, it seems difficult to accept that this factor can account for the pronounced differences in the development of the terrace system.

The dual settlement form with men in the streets and women in the "upper town" seems therefore to develop in different ways and to different degrees. It is not one phenomenon, any more than the so-called Arab city is. It is a phenomenon whose appearance and nature is as much in need of description and explanation as any other.

In this thesis, it is suggested that the terrace system and its variations can best be understood in the context of the global form of the settlement and its relation to the overall patterns of relations between and within the sexes. The reasons underlying this suggestion are

first, the variations of the terrace system seems to be intimately related to the physical and spatial nature of the settlement itself. The terrace system in its full sense, for example, seems to be possible only if there is a continuous expansion of the roofs across the streets which, as a result become entirely covered. On the other hand, the terrace system appears to facilitate social contacts between women in a society where women are said to be isolated and confined to the domestic sphere, in contrast to men. The structure and the nature of these contacts seem to vary from one settlement to another. This variation suggests a relation between the settlement form and the way in which contacts between and within the sexes are generated and controlled. Whatever explains this morphology, it clearly permits a dual use of the settlement by the sexes, more or less independently, and as such might play some part in defining and modulating their modes of communications. Moreover, the system as a whole might be held to be geared towards the generation and control of encounters between and within the sexes.

Second, the physical and spatial arrangement in these towns is clearly not the result of an overall and preconceived plan, but has evolved from the cumulative building acts of individuals governed by rules and regulations. In other words, the question of the nature of the spatial fabric of the towns seems to be intimately bound up with the question of the process of growth and the nature of the rules governing the aggregation of buildings on the ground.

In view of this twin emphasis in defining the problem, the recent work in the Unit of Architectural Studies, University College London, on settlement forms in general, appears quite suggestive. This work has suggested firstly, empirically, that settlements by virtue of the arrangements of buildings on the ground and the resulting patterns of open space, create and restrict encounter fields, and that the structure of these fields relates to the types of social network that is to be reproduced (SERC Report, 1986, pp. 42-44); and secondly, theoretically, that the study of space in general has to take account of different patterns of structuring and using space for different groups, especially men and women (Hillier B., Hanson J., 1984, pp. 223-240). It is what Hillier and Hanson call the theory of differential solidarities, in which they suggest two fundamentally different principles in the pathway to social formations and cohesion: the spatial and transpatial forms (Ibid, pp. 144-145). The main argument can be briefly stated: a society is not only based on deterministic, more rule-governed relations between its members; the probabilistic, more informal encounter events are also important to make a society what it is. The stability of a social system, that is a set of stable relations which reproduce themselves, is seen in terms of this dichotomy, that is according to whether the system of relations is more deterministic more transpatial, or more probabilistic more spatial. Defining solidarity as a membership of a social group, this distinction leads to a general theory of society based on the differential patterns in the encounter fields. The more contacts and encounters within a group tend to rely on location and spatial proximity to take place, the more the group is seen as spatially organised. The group cohesion is then more likely to be achieved on the basis of loose and diffused control, creating more informal encounter events. Whilst, the more a group tends to maintain its cohesion despite spatial separation, the more that group is seen as transpatially organised. The group cohesion is then more likely to be achieved on the basis of strong rules and structured control, creating more formal and regulated encounter events. The distinction of spatial and transpatial principles of social cohesion appears of fundamental importance because, according to space syntax theory, space is likely to be structured in the image of the relations between solidarities, especially the relation between male and female solidarities which appears to be the dominant force shaping space (Hillier B., Hanson J., 1984, p. 240).

Both of these aspects, as outlined above, seem to be present in the towns under study, but in quite a different way to for example, the European town. Understanding the relation between these aspects might therefore be a key factor to understanding the distinctive form of these cities, and moving decisively away from the too simplistic views which stress privacy, uniformity and religion, and which have dominated the studies of the Arab city until recently.

The present thesis aims to throw some light on these issues not by carrying out an anthropological study of the social structures of the towns, but by conducting an investigation aimed at the settlement form itself in four towns in which the terrace system is developed in different forms and to different degrees. These are Ghadames where, in some quarters, the terrace system expands over entire quarters and takes the form of a continuous network of pathways, clearly defined by physical boundaries, while in another quarter the terrace links are non-existent; Ghardaia and Beni Isguen where the terrace system is only developed at the level of the building blocks, and the links seem accidental, and dependent on the configuration of the ~~rooves~~ roofs; and El Oued where the terrace system does not take place at all. By this, the study aims

<u>first</u>, to try to highlight the spatial aspects of the terrace morphology and enquire how far there is any relationship between the terrace system and its variations and the global form of the towns as a whole, and through this to try to render explicit the "genotypical" properties underlying the organisation of space in these settlements.

<u>Second</u>, to look at the organisation of space at the level of the rules that govern the spatial combination of buildings in a formal sense, as shown in the way in which buildings are aggregated and the external spaces that are formed at the level of both the ground floor and the rooftops. By this, the study aims to give a description of the type of processes of building development which is potentially inclined to accommodate the terrace morphology.

<u>Third</u>, to offer in the light of the available historical data, some theoretical interpretations of the social implications of the morphological and generative

rules. If the spatial form of the city is in some sense a product of the society that creates it, then it ought to be possible to detect in the structure of the settlement itself at least some of the evidence for this relation.

The study has therefore a methodological intent as well as a substantive one. The substantive aim is to try to arrive at a better understanding of how the structure of these cities is related to the relations within and between the sexes. The methodological aim is to try to show that such studies can benefit from an architectural approach, that is one which is aimed in the first instance at describing, analysing and understanding the distinctive features of the settlement form itself.

The study is divided in three major parts, reflecting these aims. The first part is descriptive. It takes each of the four towns in turns, first introducing it briefly through what is known of its history and what can be seen through the inspection of the plan and from a visual knowledge of the streets. It then, describes the form of the houses and the domestic space structure before presenting a detailed description of the upper level terraces. This description is based on first hand data resulting from the author's own field surveys, amplified by a review of relevant published material. Published material is sparse, largely because of the restrictions on access to terraces imposed on male investigators.

This section presents also a description of the social use of space in the streets of the towns in question and at the terraces, using in the first instance the author's own descriptive data, but elaborating this wherever possible with accounts drawn from the much more extensive and useful literature. This section ends up by drawing these threads together into a theoretical account of what it is about these towns, seen spatially and socially, that might be better understood through a deeper understanding of the spatial form of the settlement and how this latter could be seen as the product of a social process.

The second part of this study is analytic. It aims to analyse the spatial structure of the towns against the background of the studies of a cross cultural sample of towns and urban areas undertaken at the research unit (*), in order to establish what, if anything, is distinctive about these towns as a group, and how they differ from each other. This section will be purely spatial in its aims. It is concerned only to arrive at a precise characterisation of the spatial structure of the towns, and establish what is about them that might be explainable by a socio-spatial theory. This section uses the space syntax methodology for settlement

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* Unit for Architectural Studies at University College London under the direction of B. Hillier.

description and analysis developed at University College London; but uses it in a new way in an attempt to capture the distinctive features of the towns under study.

The analytic section is divided into two parts. The first part provides a comparative analysis of the street structure in these towns, while the second part focusses on the spatial analysis of the terrace configuration itself, so that comparisons can be carried out on the one hand, between the street structure and the terrace system within the context of the same settlement; and on the other, between the terrace configurations within the different settlements. The spatial analysis includes the analysis of the town's structure and its "dynamics". It will be done in two ways, the analysis of space structure and simulation of movements. In other words, it aims to look at how the settlement is structured in purely spatial terms and how it is likely to be used as a system of choice for some moving fictitious individuals that have been superimposed on it (SERC Report, 1986, pp. 3-4). Real observations of movements were not possible, mainly because of the difficulties encountered by strangers to the towns, women in particular, and the restrictions imposed on them. The analytic section ends by formulating the problem to be broached in Part Three, which aims to look at the extent to which the existing structures of the towns can be seen as a product of socio-spatial rules.

The third section of the study is then generative, in that it asks the above question by computer modelling of processes of spatial growth. It uses computer simulation in an attempt to answer the question: what kind of rules must the spatial process that produced these distinctive forms have followed, and what might then be the social rationale of those rules. In other words, it seeks to give a social dimension to the analysis of space by enquiring into the social nature of the generative processes which could give rise to it. This section uses the computer in a generative mode, on the basis of the "space syntax" conception of order in space, which is defined as an outcome of restrictions on an otherwise random process of cell-growth (Hillier B., Hanson J., 1984, pp. 34-38). This section is therefore concerned with the presentation of the generative model which is developed and implemented on the BBC Basic computer and in which the output is two-dimensional plans, and also with the assessment and analysis of the outcome morphologies on the basis of the same analytical tools used in the study of the real towns.

Seventy cases of the computer generated morphologies have been looked at and the results obtained are compared with the empirical evidence derived from the spatial analysis of the towns, and the similarities and differences are then discussed. The model is intended as a means of explaining how a particular morphological outcome may be seen as, at least partly, originating from the nature of the processes of spatial growth and the internal rules of spatial combination. This type of generative process raises a number of interesting theoretical issues, and introduces a new dimension into the questions about the "causes" of settlement forms. The inference is drawn that the understanding of the building patterns in these settlements requires in fact, two kinds of knowledge:

First, it is necessary to look at the historical events and the economic and social processes in which these settlements were embedded. This kind of knowledge is valuable in establishing the context in which the physical forms have arisen; it contributes in the understanding and the social interpretation of the formal properties of the settlements, but it would never provide a proper account of the special morphological invariants that have been observed in these settlements (i.e. Hillier B., Hanson J., 1984, pp. 10-13).

Second, it is necessary to look at the relation of implication between the local rules of building aggregation and the global form (Ibid, pp. 60-61). The question of settlement form is thus strongly related to two types of laws, those governing the lawful possibilities of spatial combination and those by which social relations give meaning to formal variables (Ibid, pp. 11-16).

It is therefore essential to look in two directions; at the internal rules and processes which govern the spatial combination of buildings in a formal sense, and at the particular social and ecological environment which generate the rules. The understanding of

> "an architectural style or type requires more than simply pointing to a few important examples of it and describing their essential properties. One can claim full understanding only when one can give rules to construct new instances of the style or type" (Stiny G., & Mitchell W.J., 1980, p. 211).

The three types of information generated by the study are then reviewed in a discussion of the bearing they have on the theoretical questions of the study: the "genotypical" characteristics of this class of towns, and the relations between the sexes as reflected in these characteristics.

The conclusions of such a study are necessarily speculative, not only because the sample is small and the background information sparse, but also because the prime aim of the study is to open up questions about the "causes" of Arab settlement forms in a new way, in a way in which they might, perhaps, eventually be solved.

CHAPTER ONE: PRESENTATION OF THE TOWNS

Part One consists of the descriptive and historical presentation of the towns selected for the study. It includes material on socio-economic, historical and religious aspects, as well as descriptive material on the built forms. The aim of the introduction of such a body of data is:

i- To provide sufficient background information to the spatial analysis.

ii- To establish a basis for the interpretation and understanding of the social dimensions of the spatial structure. This information will be used as a background to interpret the results of the spatial analysis and give an idea on the social potentials of the systems.

Part One is subdivided into three sections. The first section contains the material mainly dealing with the historical aspects of the towns and their built environment. The second contains the material dealing with the social data and space uses by men and women within these towns; and the third consists of a review of some issues raised by past studies in their attempt to understand the relation between the built forms and the social structures in the towns in question, against the background of the socio-descriptive material in

Chapter One and Two.

The material used in this section derives from two sources: documentary and site surveys undertaken by the author.

CASE STUDY ONE: GHADAMES

THE GEOGRAPHICAL CONTEXT:

Ghadames is a Saharan oasis situated at the meeting point of the Libyan, Tunisian and Algerian borders (see Location Map in fig. 2.1) at about 450 kilometres from Tripoli. It is a mud-brick town with a total population of approximately 8000 inhabitants, all of whom are Muslim. It occupies a total area of about 400 ha, including palm groves and gardens. The town of Ghadames was the most important of the Libyan oases due to the availability of water and the strategic position at the trade routes used by the caravans across the Sahara (i.e. Etherton D., 1971, p. 174; Yushea B.Q., 1973, p. 91). The climate of Ghadames is extreme with temperature ranging from 8 to about 58 degrees centigrade. The climate of Ghadames is further characterised by low humidity, low rainfall and relatively frequent sand storms (Eldblom L., 1968, p. 27).

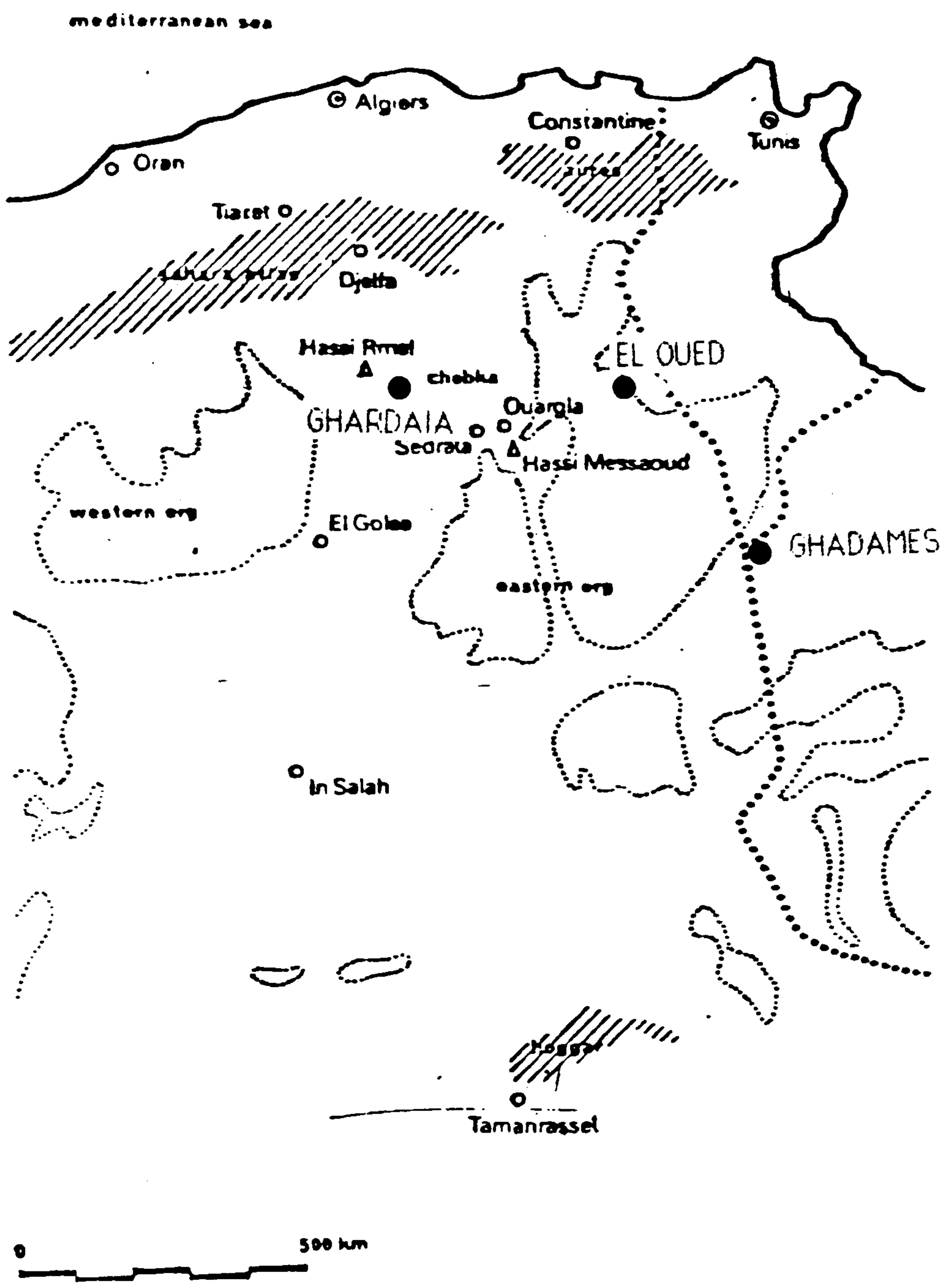

FIG. 2.1 : LOCATION MAP FOR THE TOWNS

HISTORICAL AND ECONOMIC BACKGROUND OF GHADAMES:

Not much has been written about Ghadames of a reliable nature, and even less about its urban morphology seen from a historical point of view. For the earlier period, the introduction of Motylinski's "le dialecte berbere de R'edames (De Motylinski, 1904), gives a good summary of the history of the town as it is known from the Latin, Arabic and European sources. Most of the scholars (i.e., Duveyrier H., 1861, p. 250; Motylinski, 1884, p. 10) who visited Ghadames have attempted to resolve the difficult problem of its origin. All that they had as guidances were local tales and legends.

It does seem, however, that the centre of Ghadames goes back to the remote antiquity. Ibn Khaldun states that this station in the desert was built during the Islamic era, but this was already raised as an error by De Slane (Ibn Khaldun, Trans. De Slane, 1934, p. 303) who noted that the author must be referring to the reconstruction of the town. There are some vague indications concerning the successive transformations of Ghadames in the "Chronicle" published as an appendix in the work of Motylinski (Motylinski, 1884, pp. 217-249), in addition to some interesting information about the origin and lineage of the different factions that helped to populate the oasis. The evidence of the antiquity of Ghadames is the strange vestiges that still stand today and that are reported by many travellers and visitors to the town, and of which

Duveyrier and Largeau give a detailed description (Duveyrier, 1864, p.250; Largeau, 1881, p.124).

Ghadames was for the first time reported by "The Elder Pliny" under the name of Cydamus as part of the towns that Cornelius Balbus had annexed to the Roman Empire, around year 19 of the christian era (Motylinski, 1884, p.12; Duveyrier, pp. 462; Vivien de Saint-Martin, 1863, pp. 112-122). It is then clearly established by a reliable historical document that Ghadames was under the Roman domination from the beginning of the christian era.

The Romans knew the commercial importance of the Saharan routes to the Sudan via Ghadames. After the re-conquest of Africa by the "Vandals" under the leadership of Justinian, the inhabitants of Ghadames were converted to christianity and were officially annexed to the Byzantine domination. Cydamus was then in the Byzantine Africa, the headquarter of a bishopric (B. Q. Yushea, 1973, p.16).

During the 7th century, Africa entered a new phase of its history: the Arabs already masters of Egypt since 640, started moving westwards. "Okba Ibn Nafe", a lieutenant delegated by the governor of Egypt "Amr Ibn Al Aas", headed and occupied Ghadames in 46 of the Hegira (Fournel, vol.1, 1875, pp.147-148; B. Q. Yushea, p. 20). As a consequence, the inhabitants of Ghadames adopted the Wahbite doctrine of Islam, the same religious sect practising now in the Mzab. Duveyrier has raised this historical point without giving more detailed evidence (Duveyrier, 1864, p. 250). But, it must be noted that some interesting items of information were cited in the "Abadhit Chronicles", which despite their lack of precision, provide support to these presumptions (De Motylinski, 1884, p. 18). Motylinski makes a proposition concerning the reasons relative to the division of the population of Ghadames into two main social groups, Walid and Wazit. He relates the facts to some differences in the religion such that only one group adopted the Wahbite doctrine. J. Aymo comments on this by stating that:

> "The Ghadamsi want to ignore their past adherence to the Kharijism, and sustain that the real cause of the conflict between Walid and Wazit originated from the distribution of the water of Ain Farras." (Aymo J., 1957, p. 16).

There was no reference to Ghadames by the Arab authors until the epoch of Almohades. But, during the 14th century, Ghadames enjoyed its independence and its inhabitants lived in similar manners to the Berber communities of the Mzab, under the government of the local Djemaas directed by the Sheikhs of the different factions (Motylinski, 1884, p. 20; Duveyrier H., 1864, p. 264).

After the definitive establishment of the Turks in Tunis, the Bey Derouich headed an army in the direction of Ghadames and imposed a tax to be annually paid by the inhabitants (1592-1593). Until the middle of the 18th century, Ghadames remained under the regency of Tunis. In 1845, James Richardson, a British official, was sent to Ghadames in an attempt to assess the commercial advantages that Britain might benefit from by taking control over the caravan routes from Tripoli to Sudan via Ghadames (Yushea B.Q., 1973, p. 106). The French, on their side, after the complete occupation of southern Algeria, were trying to annex Ghadames. It was only in 1943 that Ghadames became part of the French colony to North Africa (Ibid, p.130).

According to the "Chronicle" of Ghadames translated by Motylinski, the first who settled in Ghadames were "Ibn Mani" and "Ibn Mazir", who were originally from the Fezara. This town was several times destroyed and rebuilt. The "Ibn Mani" were divided into three sections, one constituted the quarter of "Beni Darrar", the second the quarter of "Beni Fadhl", and the third "Ournoura". The leader of the latter had a son Ouadjellid who gave birth to Walid and Wazit.

The two brothers were in continual war for power. Walid settled on the northern side, while Wazit occupied the south. The conflict grew deeper between them and was even transmitted to younger generations. This historical fact seems to provide some information as to the pattern of growth of the different quarters of Ghadames. It gives some evidence of the simultaneous growth of the separate quarters of the settlement.

In the light of the historical data, it can be concluded that Ghadames played a considerable role as a major trans-saharan caravan centre. It was highly integrated into the Saharan commercial network, especially in the caravan route to Sudan, and was a major link with the Tuareg territory. Trading was the most important economic activity carried out by the inhabitants of Ghadames (Eldblom L., 1968, pp. 39-42). The slave market from the Sudan constituted a cheap labour for agriculture, which provided the basic products of life (i.e. dates, crops, vegetables). Meat was provided by the Nomadic Tuareg. The abundance of water in the town helped agriculture to flourish, which is practised in three levels as it is the case in most of the Saharan oases.

The local industry mainly consisted of subsistence production, but the town was very famous for its tanned leather which was exported to different parts of North Africa and Sudan (Ibid, p. 40). Today, Ghadames benefits as the rest of Libya, from the petroleum revenues and many new developments and local industries are taking place within the city.

THE SOCIAL STRUCTURES:

In Ghadames, there are four distinct "communities" which, although separated by language, appear also to be highly integrated and consolidated (Eldblom L., 1968, pp. 42-55; Yushea B. Q., 1973, p. 54-73). These are as follows:

i- An Arabic-speaking community called "Ouled Bellil". They inhabit a separate quarter known by the same name (see fig. 2.3, p. 43). They have been there for some considerable time; certainly long before written records were kept (Eldblom, L., 1968, p. 42).

ii- A Tuareg-speaking community locally known as "Lamtayyan". These inhabit a separate area called "Addaharat", situated to the west of the town. They did not occupy houses, but lived in tents spread over an open area, surrounded by their livestock.

iii- A Hausa-speaking community, consisted of freed slaves who originally served the Berber-speaking community. They inhabit as well the quarter of Ouled Bellil.

iv- A Berber-speaking community which constitutes the core of the Ghadamsi society. Its members are divided into two groups, the Walid and the Wazit. The former occupy the quarters of Darrar and Mazigh, the latter the streets of Jarassan, Tingesin and Taferfara (see map in fig. 2.3, p. 43).

The society of Ghadames is clearly divided into several groups, both geographically and socially (Eldblom, 1968, pp. 43-55), and this division exists to some extent in the language. For instance, there are a number of differences between the dialect of the Wazit and Walid. Women's speech also differs from the men's and in particular some items of lexicon are only used by the women (Motylinski, Paris, 1904, p.67). The division of the resident population into social groups is mainly apparent through water ownership, land tenure and palm trees ownerships. Eldblom gives a detailed description of the formation of the different social groups on the basis of the translation of the "water book", kept in the oasis for many centuries. He also establishes a land tenure map (Eldblom L., 1968, p. 50) and notes that the land, water and palm trees are collectively owned by the groups (Ibid, p.114).

The terrace system, which consists of the rooftops of the houses interconnected by a system of walkways, exists only in the last quarters, the Walid and the Wazit. The Ouled Bellil quarter, although densely built as Walid and Wazit, does not present any physical characteristics reminiscent of the terrace system: the houses are only one storey high, the streets are wider and not covered up, and the rooftops are not interconnected.

SOURCE MATERIAL AND DATA GATHERING:

Several problems and difficulties have been encountered in collecting data about Ghadames, one of which is the scarcity if not the total lack of existing useful material about this town. The only published document is the plan of the town produced by Eldblom in 1962. This is an updated map of an earlier plan of the town drawn in 1862 by a French expedition (Eldblom L., 1968, p. 40).

The primary source material for Ghadames has been:

- the ground plan of the town at a scale of 1:1000, prepared by the Municipality of Ghadames on the basis of Eldblom's plan, and only available locally.

- a fairly recent aerial photograph of the town (July 1979), provided by the Ministry of Agriculture, Tripoli, at a scale of 1:6000 (see fig. 2.2, p. 40).

The field survey was carried out at three levels:

i- <u>At the level of the town</u>: The updating of the ground plan of the whole town which has involved the checking of the accuracy of the map itself and adding several missing streets and cul-de-sacs; the mapping of all entranceways of the individual buildings and houses and all entrance gates to the separate quarters; the recording of building uses other than residential, and adding street furniture, especially the built-in masonry benches used by men.

ii- <u>At the domestic level</u>: Many houses have been visited, at least five in each quarter. Plans and elevations for ten of these houses have been measured up and mapped. The drawings of the house plans have been prepared locally in Ghadames, so that missing information could be added on site.

iii- At the terrace level: The survey of the terraces has posed great difficulties. No roof plan of the town has been drawn or published so far. Inspite of these technical difficulties, it was possible to make a full survey of one roof area in the Wazit quarter (*).

The most difficult task in the terrace survey was to identify a reference point, a kind of "landmark" so that a roof area can be demarcated on the aerial photograph . Two reference points have been used, one is the "dog-leg" passageway which is clearly visible on the aerial photograph and the other is "Aicha's house", which is one of the mapped houses already located on the ground plan and which is in close proximity to the "dog-leg" passageway. From these reference points, an area covering approximately 30 houses has been marked on the enlarged copy of the aerial photograph , and from which an approximate plan has been drawn. This plan forms the basis for the production of the final map used for the analysis of the terraces.

The survey of the terrace area was carried out on three stages. The first stage consisted of identifying the selected area on site by walking around several times, starting from the "dog-leg" pathway, in order to become more familiar with its structure. The second stage was

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* The reason for choosing Wazit quarter for the survey of the terraces is that the girls who were my local guides, lived in this area; so I had much easier access to the rooves at any time of the day or night.

to record and mark all the parts that cannot be used for walking, such as the voids of the upper courtyards, light shafts and partition walls. The final stage of the mapping was to walk around again several times, and check where access is possible, without taking into account detailed information such as steps to separate houses, difference in levels, doorways to the houses, upper front door decorations and so on. The final map is presented in figure 2.10, p. 60.

THE BUILT ENVIRONMENT:

Very little material has been written about Ghadames. Apart from some travellers' accounts at the beginning of the century already referred to, such as Duveyrier, Largeau, Motylinski, Dr Amat and the more recent work by Eldblom, Yushea and Yedder, knowledge concerning this town from documentary sources remains very scarce. However, the distinctive form of housing in Ghadames has caused some comments by visitors from the early explorers to the present day. Duveyrier who visited the town in 1864 described the houses as being large and well ventilated, whitewashed to protect them from the heat and of several storeys. He also noted that the streets were completely covered to maintain the temperatureascool as possible (Duveyrier H., 1884, p. 262). Davis, describing Ghadames with no reference to the terrace system writes:

"The houses are built like those of Tozar and

> Nefta of bricks baked in the sun, mud and palm tree wood. The public buildings offer nothing remarkable. The streets which are narrow scarely admitting two camels to walk abreast, are all covered in to keep them cool" (Davis N., 1954, p. 197).

Aymo writes that

> "The form of construction is limited to the range of building material available in the surrounding area -mud, lime, palm trunks...-. It is a unique architecture which has developed such a comprehensive response to the climate" (Aymo J., 1958, p. 119).

Elsewhere describing the terraces of Ghadames, he comments:

> "The roof level reached by stairs and contains the kitchen and a store for bedding is the domain of women; they are the only ones who have access to it during the day" (Aymo J., 1958, pp. 187-188).

Yushea on his part adds that the inhabitants of Ghadames have developed a house plan and a grouping of dwelling ideally adapted to provide protection from the inhospitable climate (Yushea B.Q., 1973, p. 82).

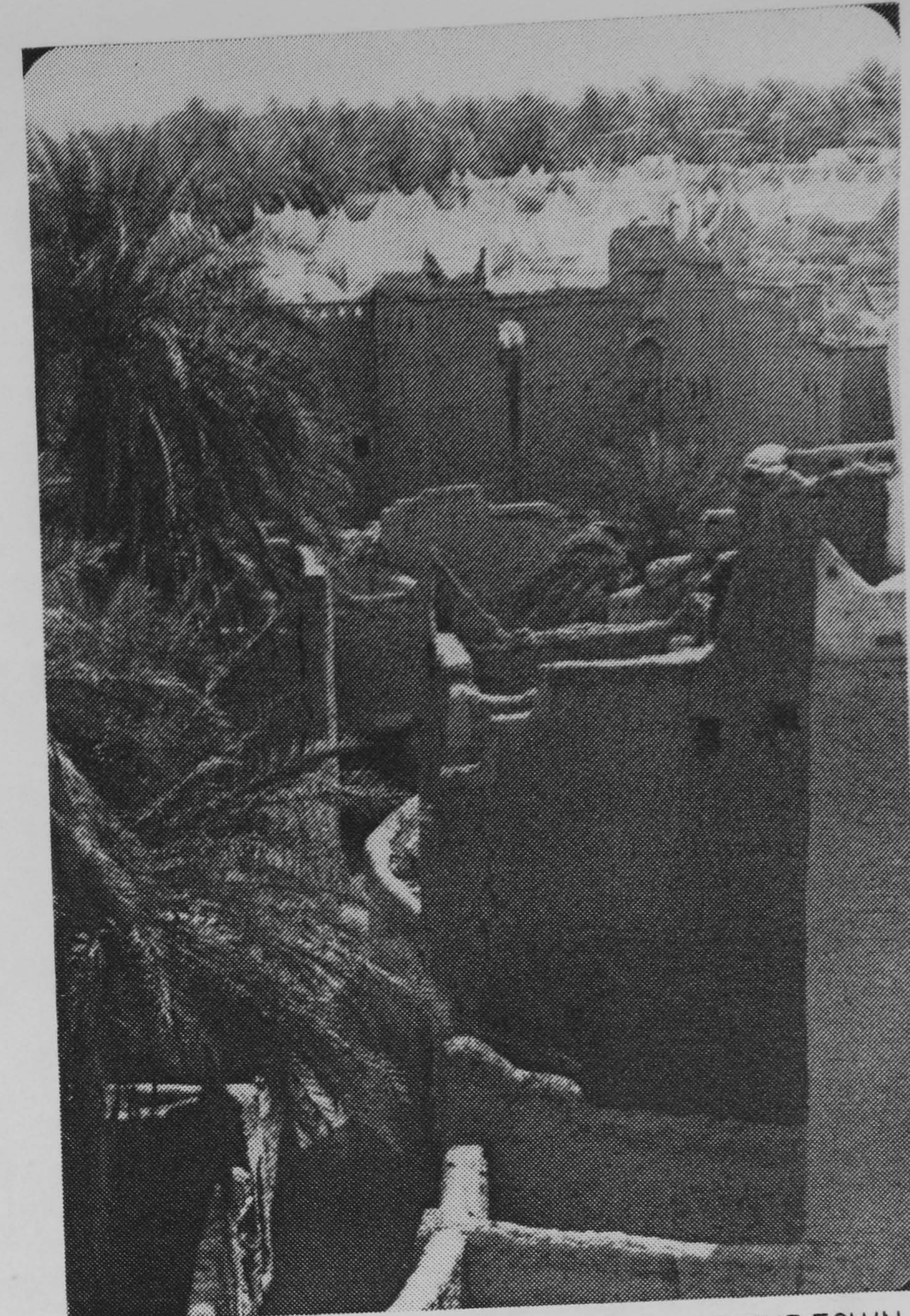
These descriptions are sketchy and incomplete, and for this research, their value remains limited, and a more detailed description is necessary. This will form the main concern of the ensuing sections.

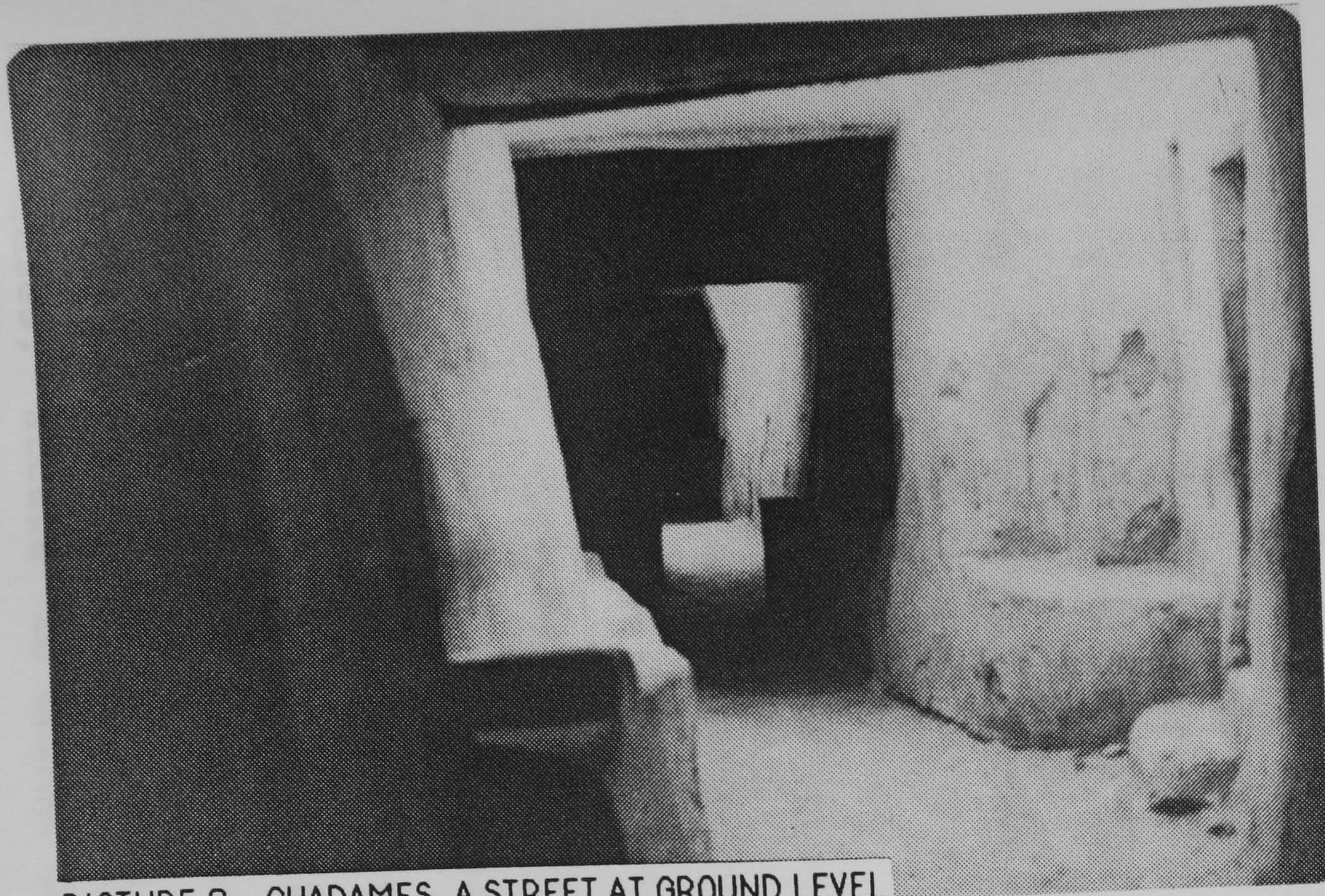
In Ghadames, the houses are grouped together to form a very homogeneous aggregate, in which the main component is constituted by the quarters of Darrar, Wazit and two smaller quarters, Mazigh and Ouled-Bellil. The first is located at the north-western side of the main core and the second at the south (see Aerial Photo in fig. 2.2). At about 200 metres east of Darrar, there is another small hamlet Amaenish, which is administratively annexed to the quarter of Wazit.

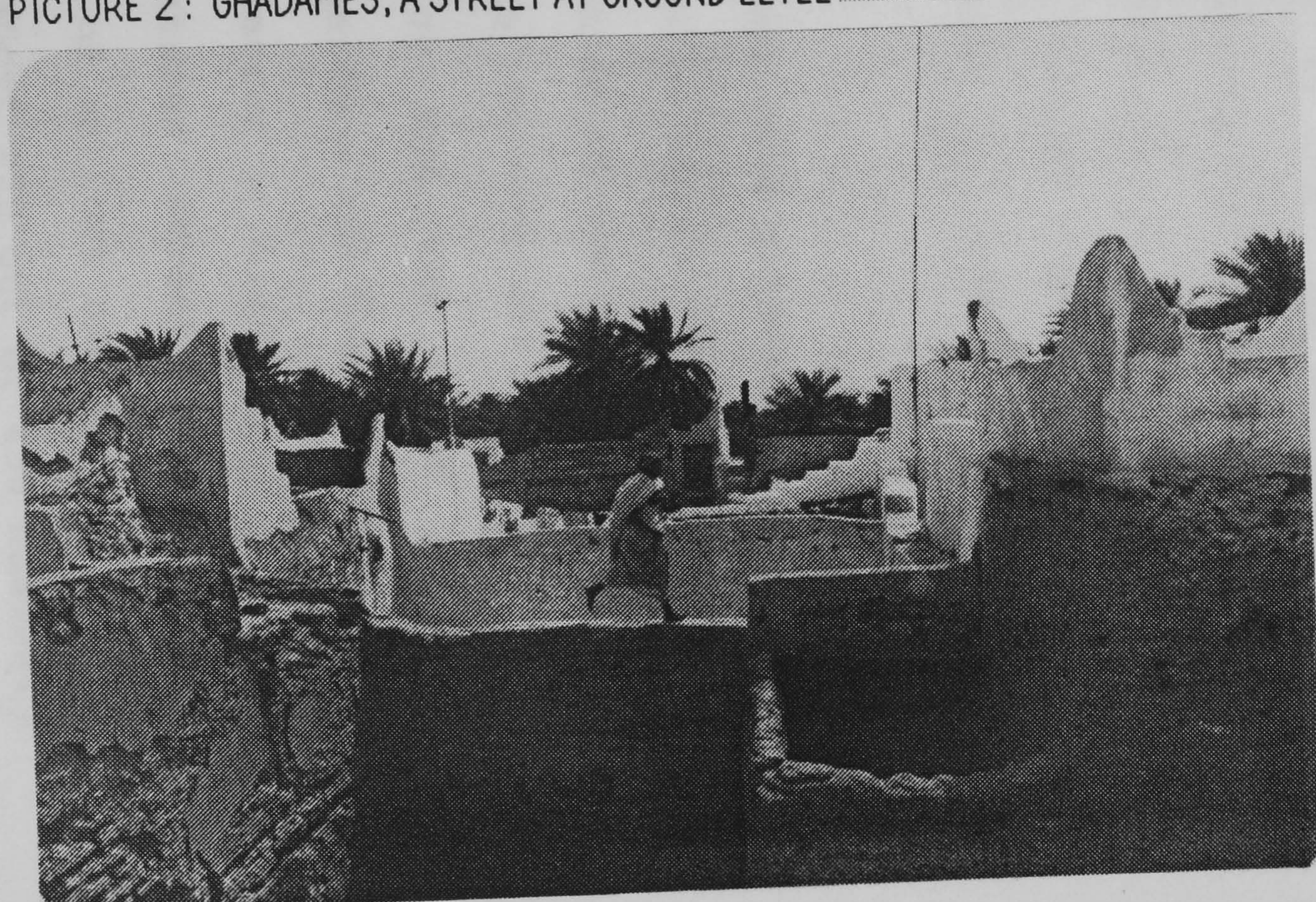
Ghadames presents certain characteristics that are particular to this oasis. Most of the streets in Wazit, Darrar and Mazigh are entirely covered up and form veritable tunnels, running under the houses that are in most cases three to four storeys high (see Picture No. 1). These streets open out occasionally into covered squares and are lit by small light wells (Tenawt) in the roof overhead (see Pictures Nos 2, 3). The major streets are usually two to three metres wide and are furnished with built-in masonry benches (Tasquimott) along the external walls of the houses. These are used by the male population for their meetings (Yushea B. Q., 1973, p. 75).

The location of the settlement seems to be influenced by the proximity of the main water source, the fountain of Ain Al Farras, which is only at 100 m away from the geographical centre, occupied by the market square known as Suq El Gaddous. This latter indicates the limits of the Walid and Wazit quarters, which are con-

FIG. 2.2 : GHADAMES, AERIAL PHOTOGRAPHY


PICTURE 1 : GHADAMES, GENERAL VIEW OF THE TOWN


PICTURE 2 : GHADAMES, A STREET AT GROUND LEVEL


PICTURE 3 : GHADAMES, VEW SHOWING LIGHT SHAFT AT ROOF LEVEL

nected only by means of a single gate from each quarter that used to be kept locked at night. The market square (10 x 15 metres) is bounded up at the east and the west by the two main mosques attributed to the two quarters, Jamaa Atikh for the Walid and Jamaa Yunes for the Wazit (see Town Map in fig. 2.3).

The Tuareg settlement is situated outside the walls of the town, at the western part of Ghadames, and on both side of the road that leads to Tounin, a small oasis, at 2.5 kilometres west of Ghadames.

DARRAR:

Darrar the largest quarter of the town, is located at the northern part, and joins to Mazigh and Wazit at the south (see Ground Plan in fig. 2.4). It is constituted by 450 houses approximately, grouped together to form a very compact aggregate occupying an area of approximately 4.5 hectares.

The access to Darrar is through five gateways, one of which is from the main public square of the town and links the quarter to the outside of the town. It is therefore the only access to the visitors. The second gateway links Darrar to Mazigh and the three others link the quarter to the gardens and the agricultural fields. The ground plan of Darrar in figure 2.4, shows a very irregular and tortuous street network which demarcates blocks of houses of various sizes. In many cases, access to houses (about 230 out of 450 houses)

FIG. 2.3 : GHADAMES, GROUND PLAN

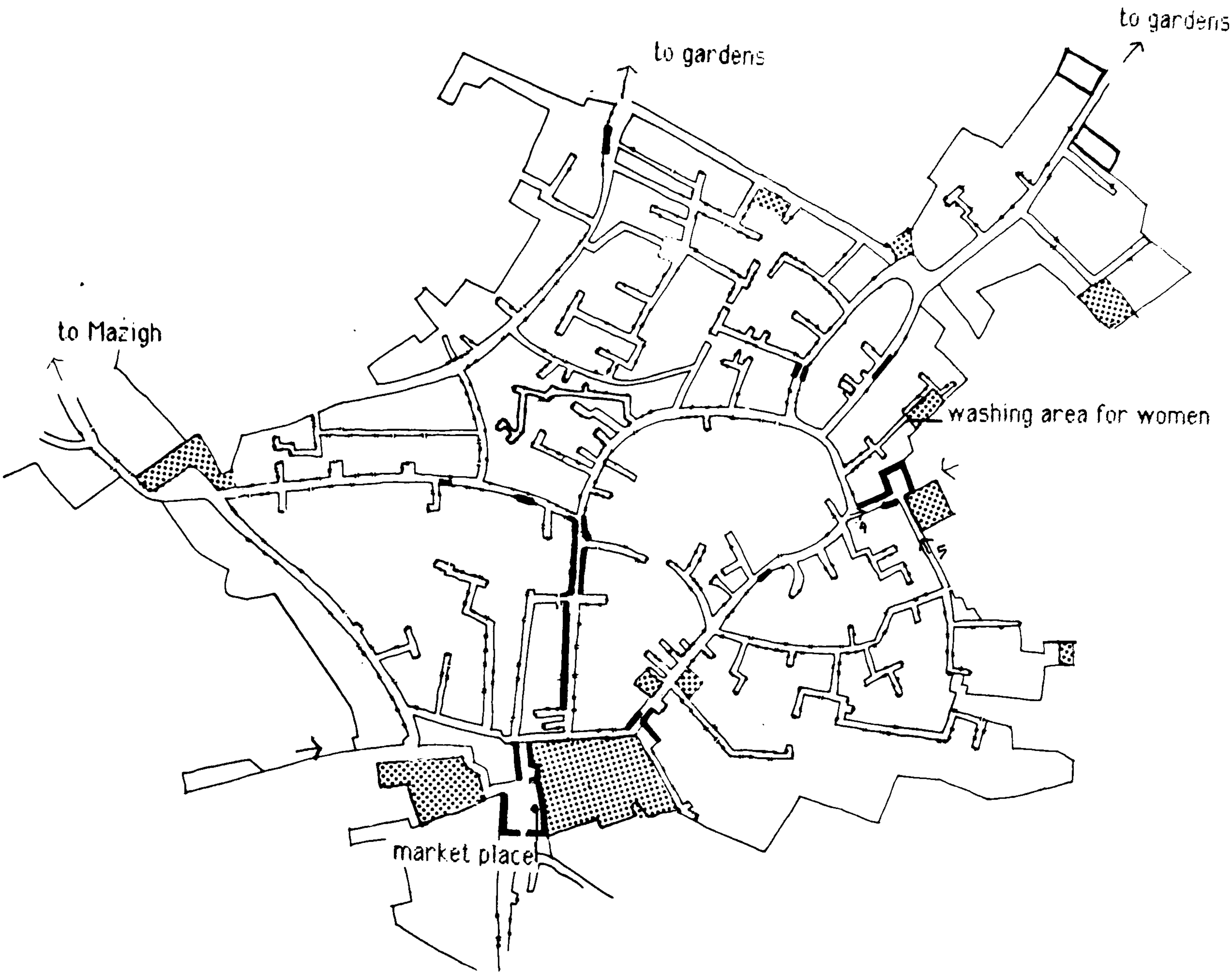


FIG. 2.4 : GHADAMES, GROUND PLAN OF DARRAR

masonry benches for men
mosque
building line
access to buildings
5 → see Picture 5

North

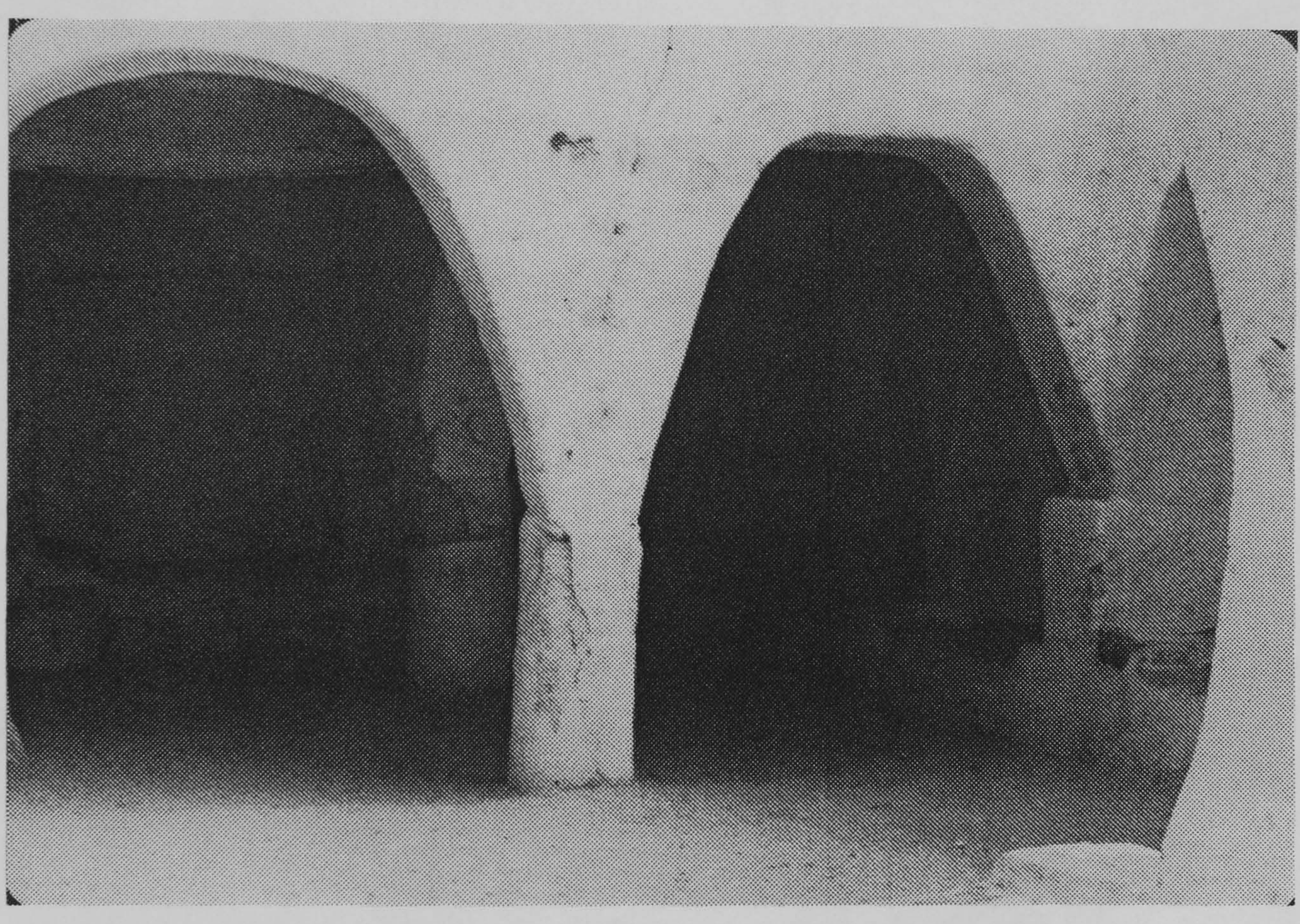
is gained by narrow and very dark cul-de-sacs, forming a rather labyrinthine pattern. The ground plan shows also the limited number of the public buildings and spaces, including mosques, washing areas for clothes and kitchen utensils, public baths, and several communal sheds mainly to house goats. Most of these facilities are located at the periphery of the quarter. The main mosque at the southern edge of the quarter is adjacent to the main public square of the town, but has its entrance on the adjoining street of the quarter rather than on the square itself. Four smaller mosques used also as men's houses are distributed around the periphery of the quarter. The female washing area is located at the joining point of Darrar to Mazigh, together with by a small mosque reserved for women's use from both quarters.

The plan also indicates the street furniture, or more precisely the built-in masonry benches locally termed "tasquimott", where men sit and even have their siesta during the hottest hours of the day (Yushea B.Q., 1973, p. 75). These are mainly on the streets which run from the main mosque towards the interior of the quarter, and along the street which runs in the direction of the joining point of Mazigh and Darrar. Other benches are built close to the entrance gates of the quarter. In addition to the main public square, two other smaller squares are built at the eastern and western periphery of Darrar. Pictures 4 and 5 show views of the square which is totally covered up by an arcade, and on which gives a small mosque. The masonry benches are constructed all around the perimeter of the square. The other square is also covered up and is bordered by a mosque.

WAZIT:

Wazit is the second largest quarter in Ghadames (see fig. 2.5). It comprises about 350 houses, 136 of which are serviced by cul-de-sacs, and occupies an area of approximately 2.5 hectares. This quarter expands linearly southwards of the main town square, and has six entranceways, one of which is from the main public square. The second main entrance point is at the meeting point of Bellil quarter to the south. All the other gateways link the quarter to the gardens and fields. The main characteristic of this quarter is the long street (about 400 metres) known as "Jarassan street" which forms a sort of a "dorsal spine" running north-south across the quarter and from which branch all the other streets. Picture No. 6 shows a view of this street, along which masonry benches are built. These are wide enough and are used as sleeping area during the day by old men. On this street are two squares entirely covered up. Picture No. 7 shows a view of these squares with built-in benches which are used as meeting places for men of this quarter.

The ground plan shows in addition to the main mosque, three smaller mosques located at the periphery of the



PICTURES 4, 5: GHADAMES, COVERED SQUARE IN DARRAR FITTED WITH MASONRY BENCHES

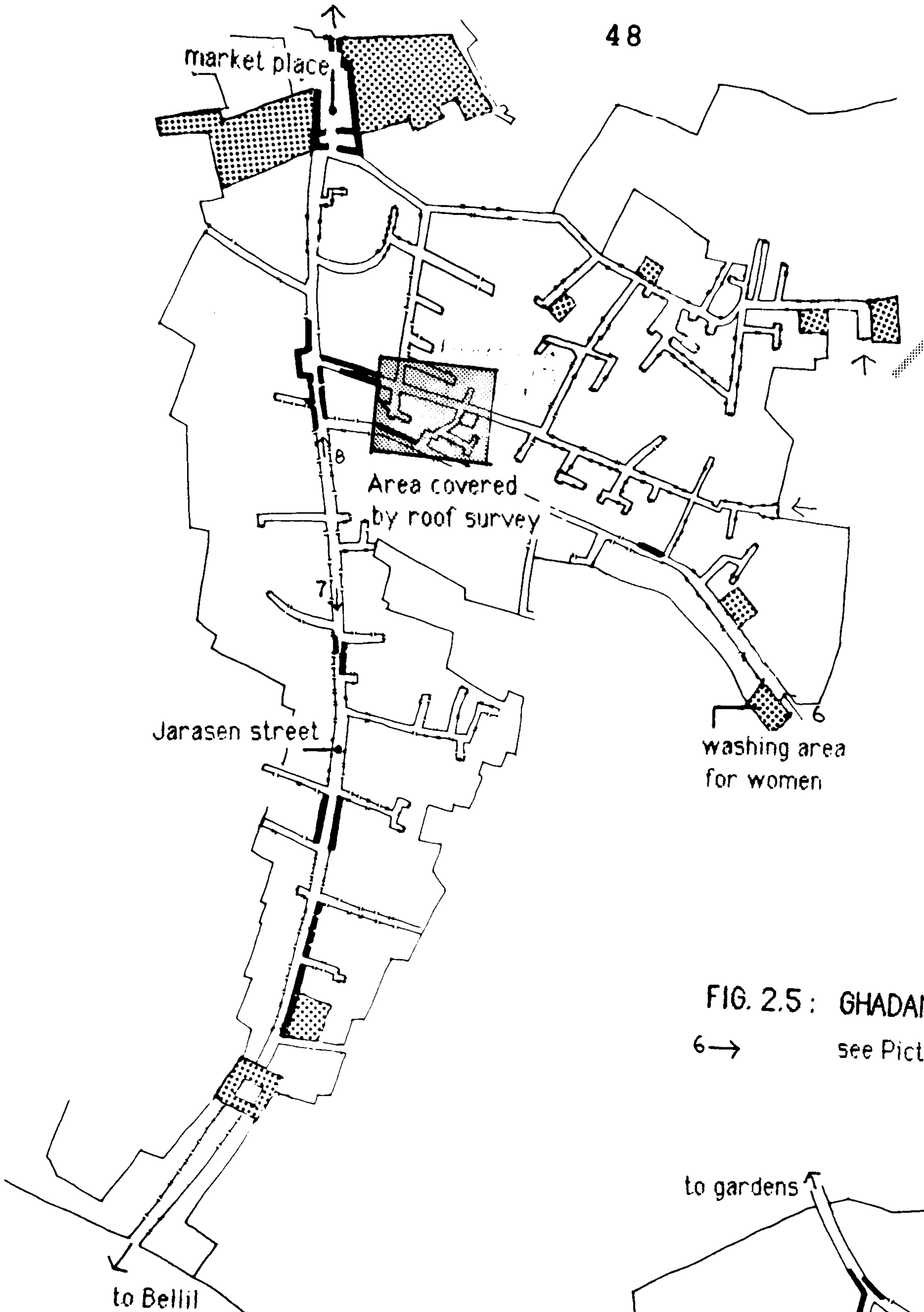


FIG. 2.5 : GHADAMES, GROUND PLAN OF WAZIT

6→ see Picture 6

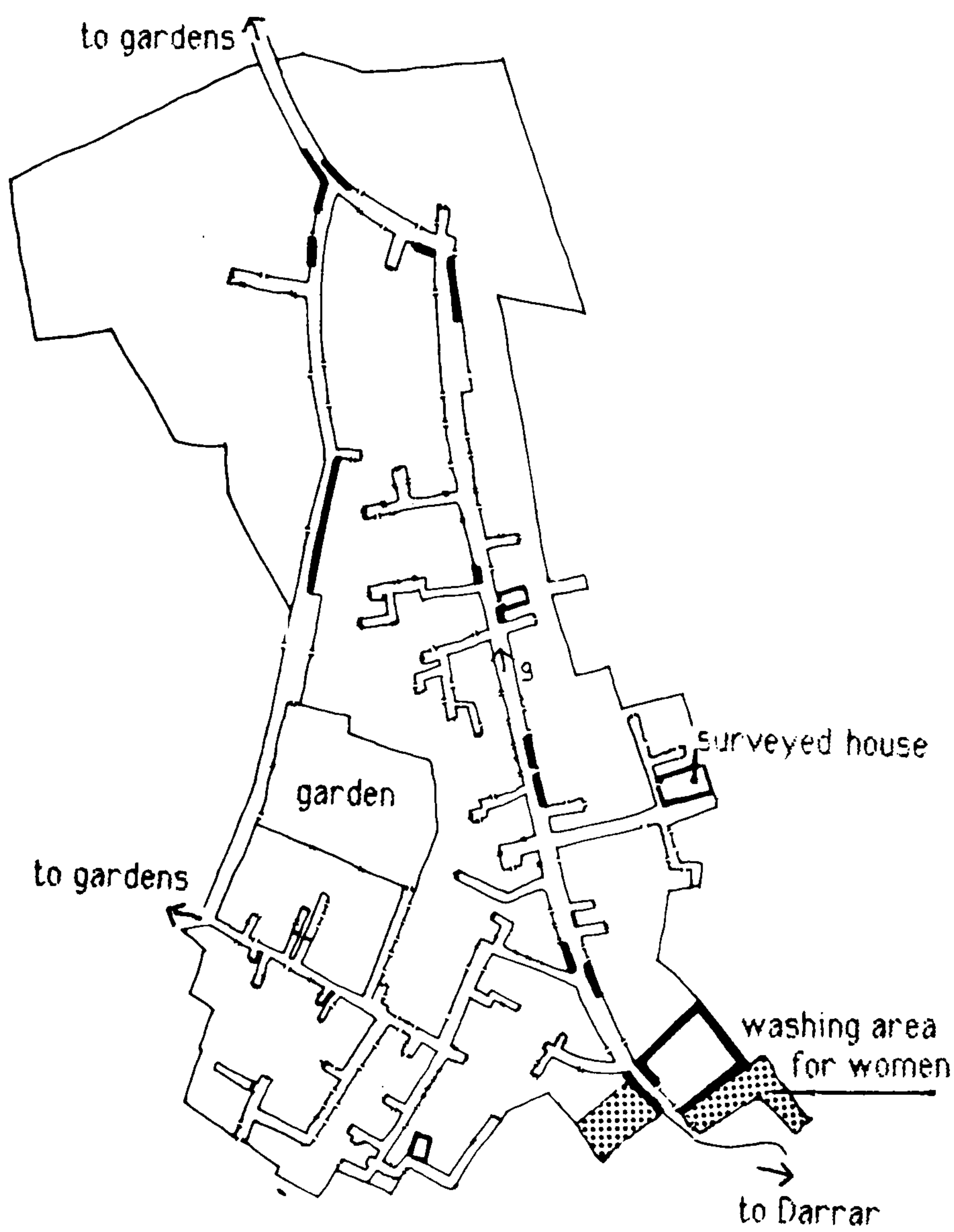


FIG. 2.6 : GHADAMES, GROUND PLAN OF MAZIGH

masonry benches for men

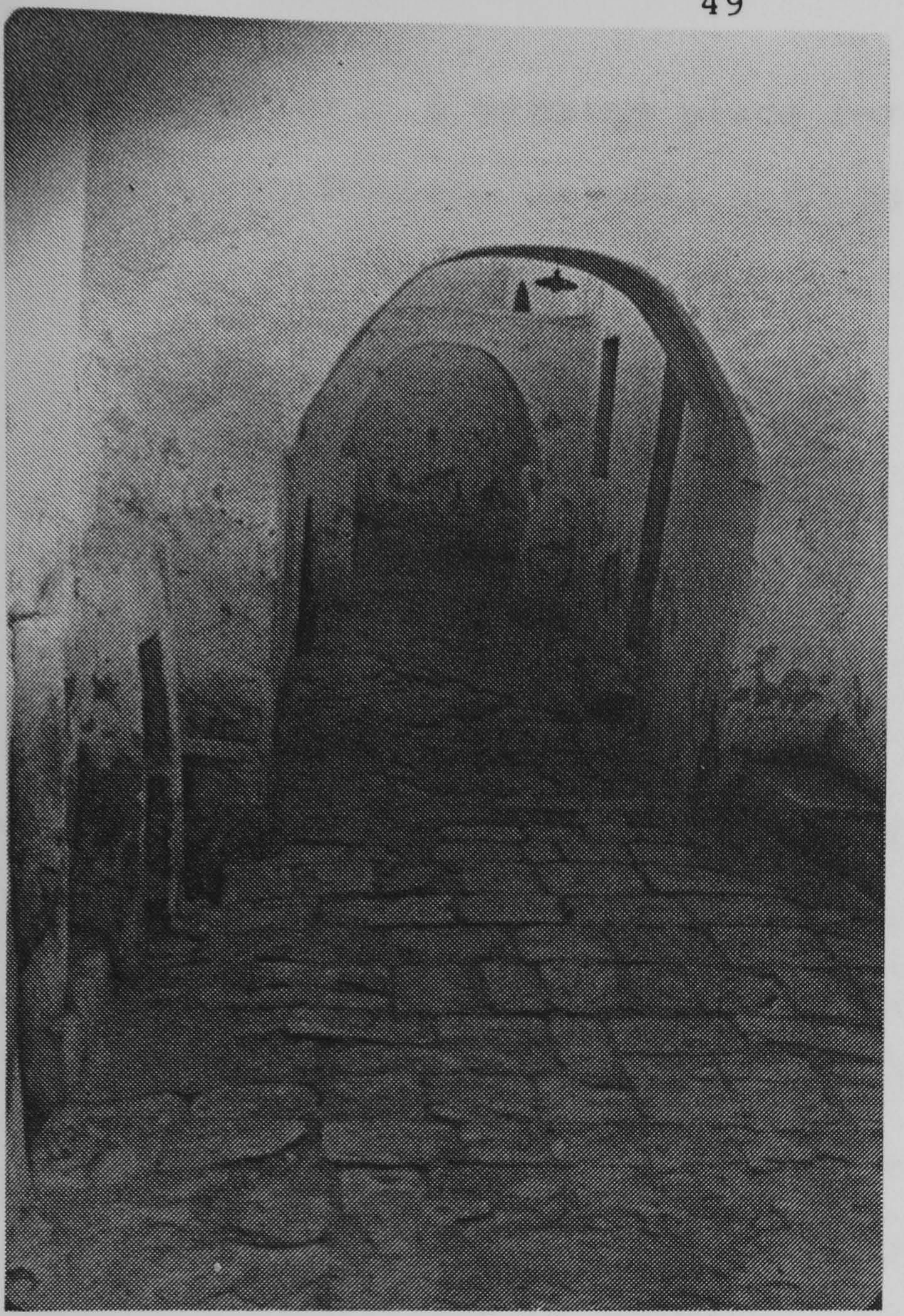
mosque

building line

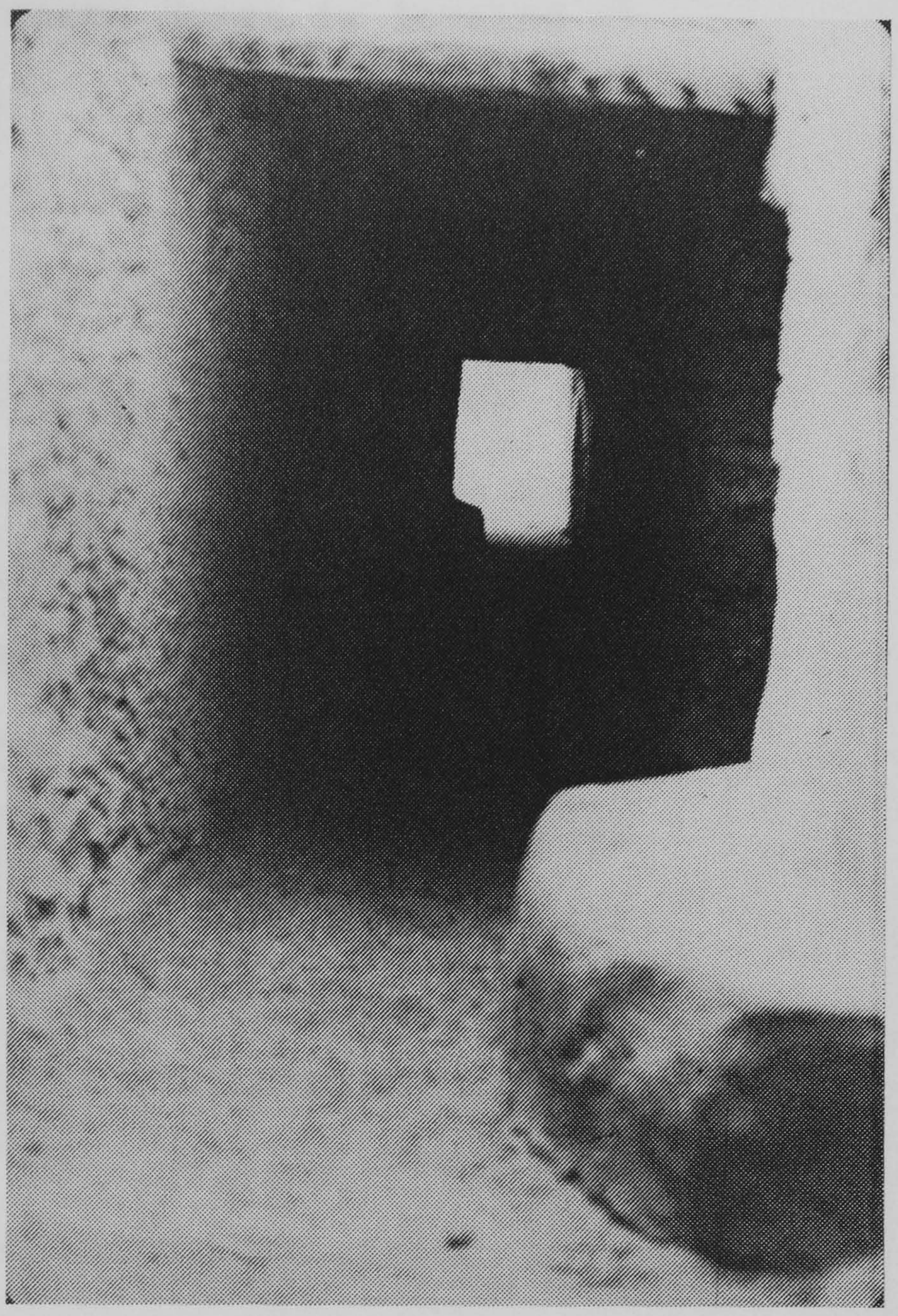
access to buildings

9→ see Picture 9

N



entrance to washing place on the left for women



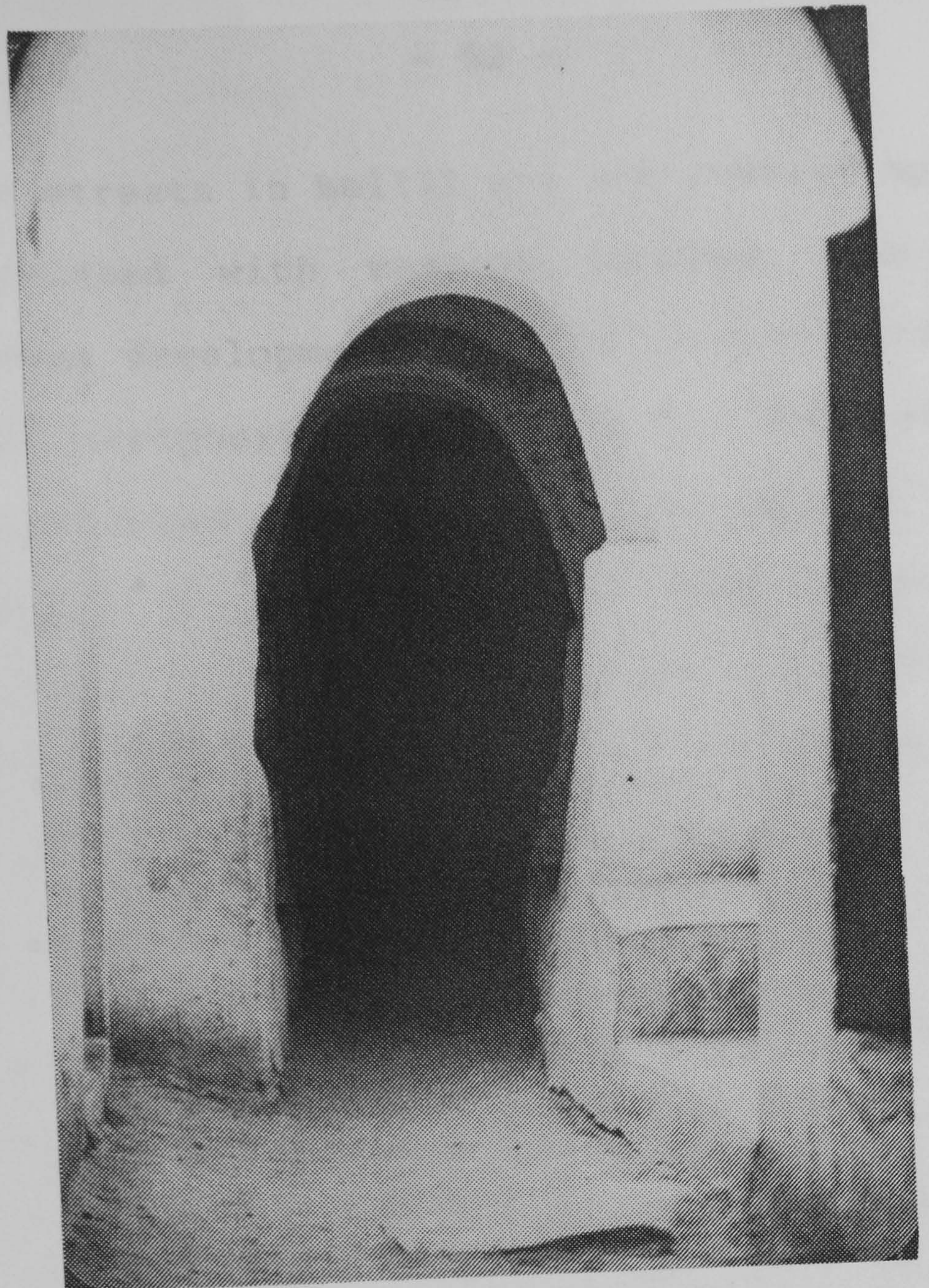
PICTURES 6, 7, 8: GHADAMES, VIEWS OF STREETS AND SQUARE IN WAZIT quarter. A washing place for women is also provided (see Picture No. 8), and the goats house is located at the eastern edge of the quarter.

MAZIGH:

It is a very small quarter, constituted only by 178 houses. The quarter expands linearly towards the north and is linked to the outside by means of five gateways, one of which links this quarter to Darrar (see fig. 2.6, p. 48). The other gateways connect Mazigh to the palm grove gardens. The main streets in this quarter form one large ring, on which are attached several cul-de-sacs. The street which runs from Darrar through Mazigh is fairly regular and is furnished with several masonry benches built at different intervals from each other. Picture No. 9 shows a view of this street with dark atmosphere prevailing in it. The pictures are taken from the sections of the street that are lit by means of shafts in the terraces overhead, giving occasional light and ventilation. The public facilities in this quarter consist only of one mosque with the washing area, a communal wood storage and the communal stable, all located at the eastern periphery of the quarter.

BELLIL:

Bellil is the only quarter of the town where the terrace system is not developed. Unlike the other areas,



PICTURE 9 : GHADAMES, A STREET IN MAZIGH

PICTURE 17: GHADAMES, VIEW OF TERRACES

the streets in Bellil are not covered up and are not furnished with masonry benches. The quarter takes a linear development with the largest street located at the periphery (see fig. 2.7). Part of this street is constituted on one side by the remains of the town walls. It links on one extremity to Wazit on "Jarassan street". At the linking point, a mosque and a public square are situated. Two other smaller mosques are built on the peripheral street.

The quarter contains about 195 houses, all of which are one storey high and are built around a courtyard. According to Etherton, in Arab towns, when the houses are only a single storey high, the courtyards of the individual houses interconnect to each other "so that women can pass from one to another without having to walk in the streets" (Etherton D., 1971, p. 174). This is not the case in Bellil. The mapping of all existing entranceways to houses shown on the ground plan in figure 2.7, as well as the visits to their interiors disclosed no internal links between houses. The plan of one house in this quarter and inserted in figure 2.8 shows an almost random disposition of the rooms around an interior open space, with a yard used as a stable at the rear of the house. The kitchen, the living room and bedroom have their access from the central open space. A staircase links the ground floor to the roof terrace used in summer for sleeping. The terrace is surrounded by a parapet of about 2 metres high, and no link with other terraces exist. However and unlike the

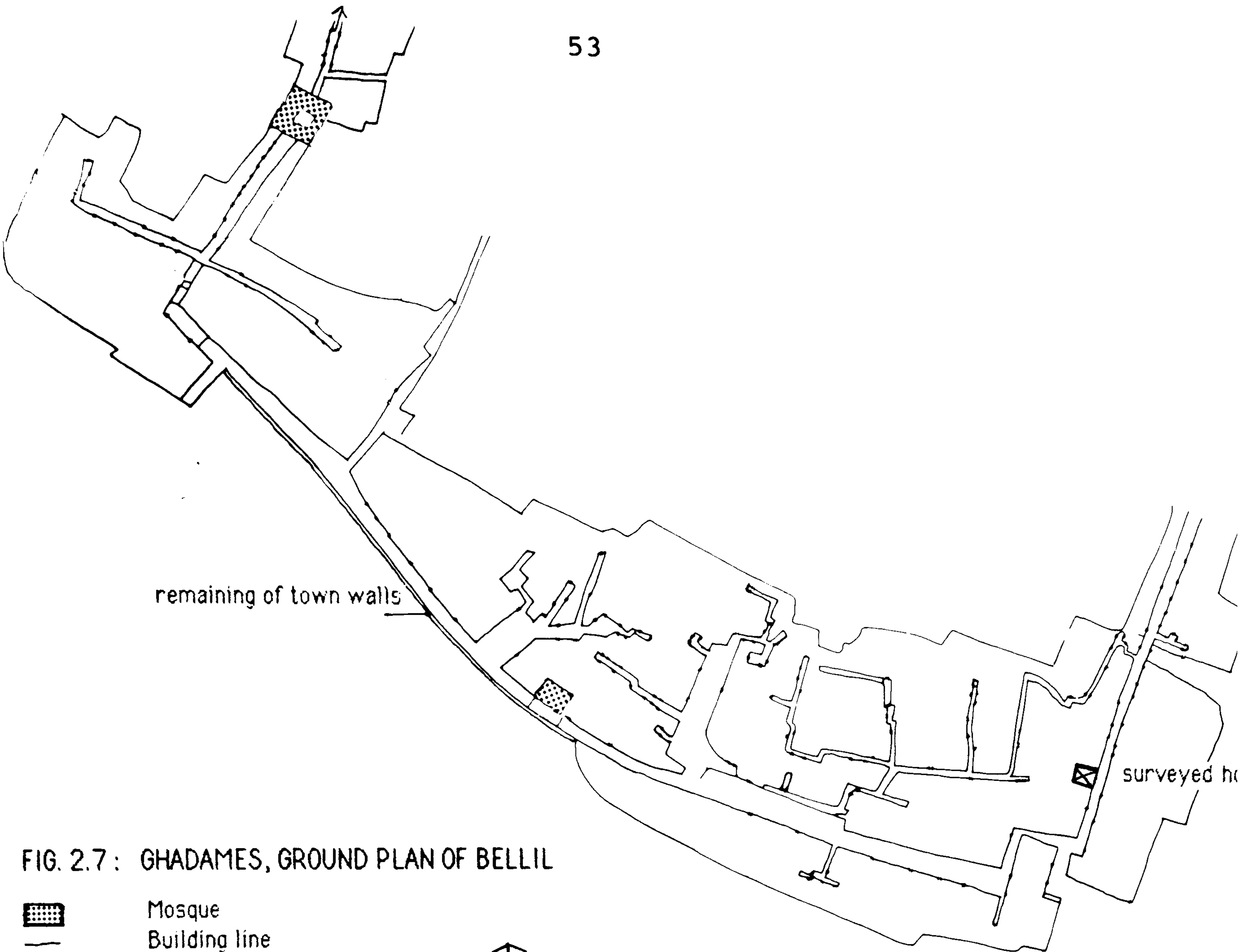


FIG. 2.7 : GHADAMES, GROUND PLAN OF BELLIL

Mosque
Building line
Access to buildings
North

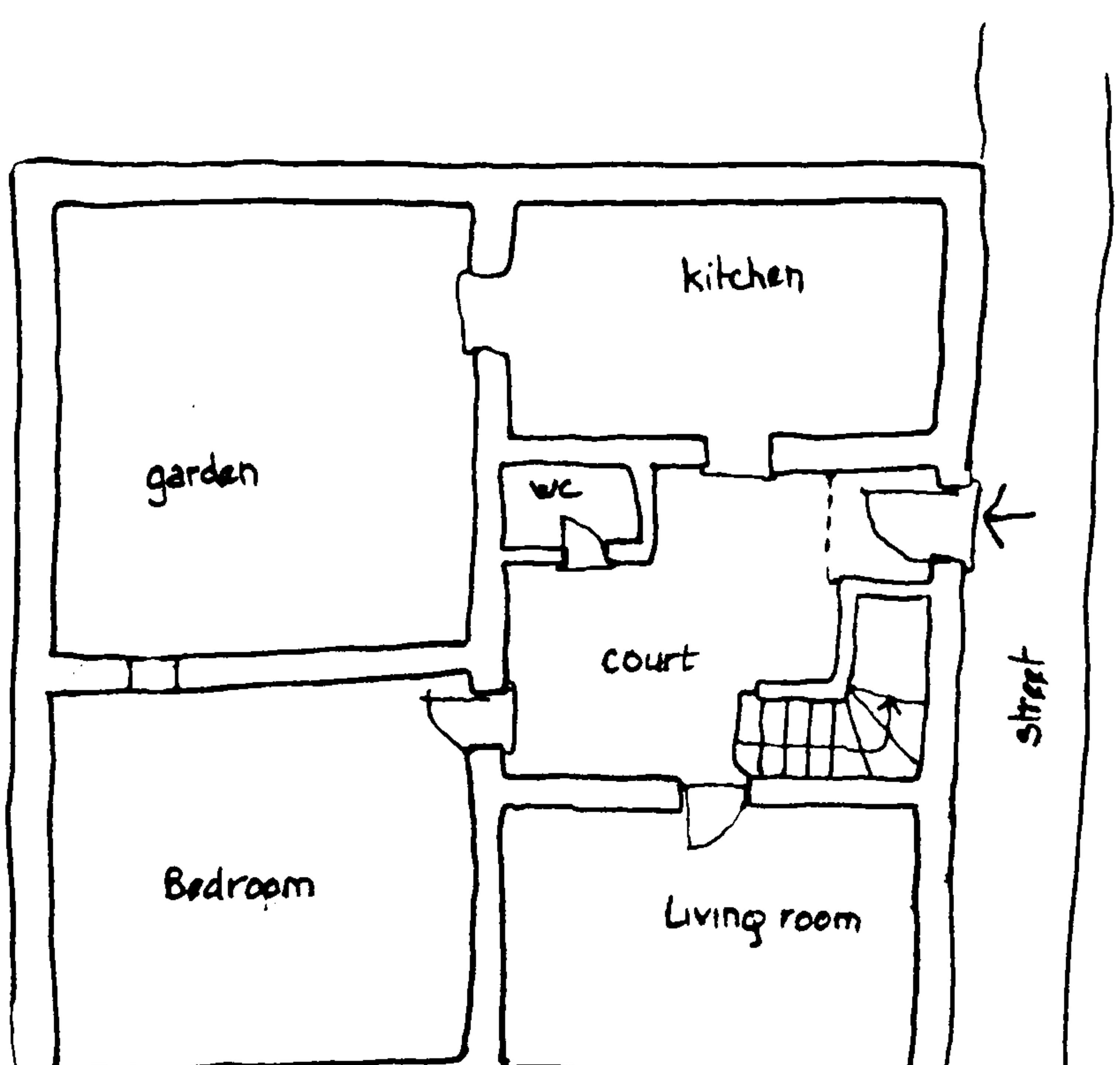


FIG. 2.8 : GHADAMES, HOUSE PLAN OF BELLIL

three other quarters, it is the only area where women gather on the streets outside their homes unveiled (*).

DESCRIPTION OF THE HOUSES IN GHADAMES:

The following description is based on visits to numerous houses and on the visual inspection of 10 house plans taken from the different parts of the separate quarters. The location of these houses is marked on the ground plan of the town. This section is concerned only with the description of the houses in the quarters where the terrace system occurs.

With the exception of Bellil quarter, the houses in Ghadames consist of three to four storey buildings. These are invariably built around a central living room, acting like a courtyard. On entering the house (see House Plan in fig. 2.9) from the street, one finds oneself in a small hall (locally termed ajard). On one side or on both of this, is situated one or more store rooms (taddart) fitted with doors, where agricultural implements, tools, charcoal, wood are stored. Sometimes one of these rooms is used as reception room for the male guests. At the far end of the entrance hall is situated a staircase which leads to a door giving in

* During the site survey, I was greeted by a group of women in the streets of Bellil area. Several women and children came out of their homes to meet me and gathered outside, all unveiled. One of the women has even helped me holding the measuring tape, when I was checking and updating the ground plan for this area.

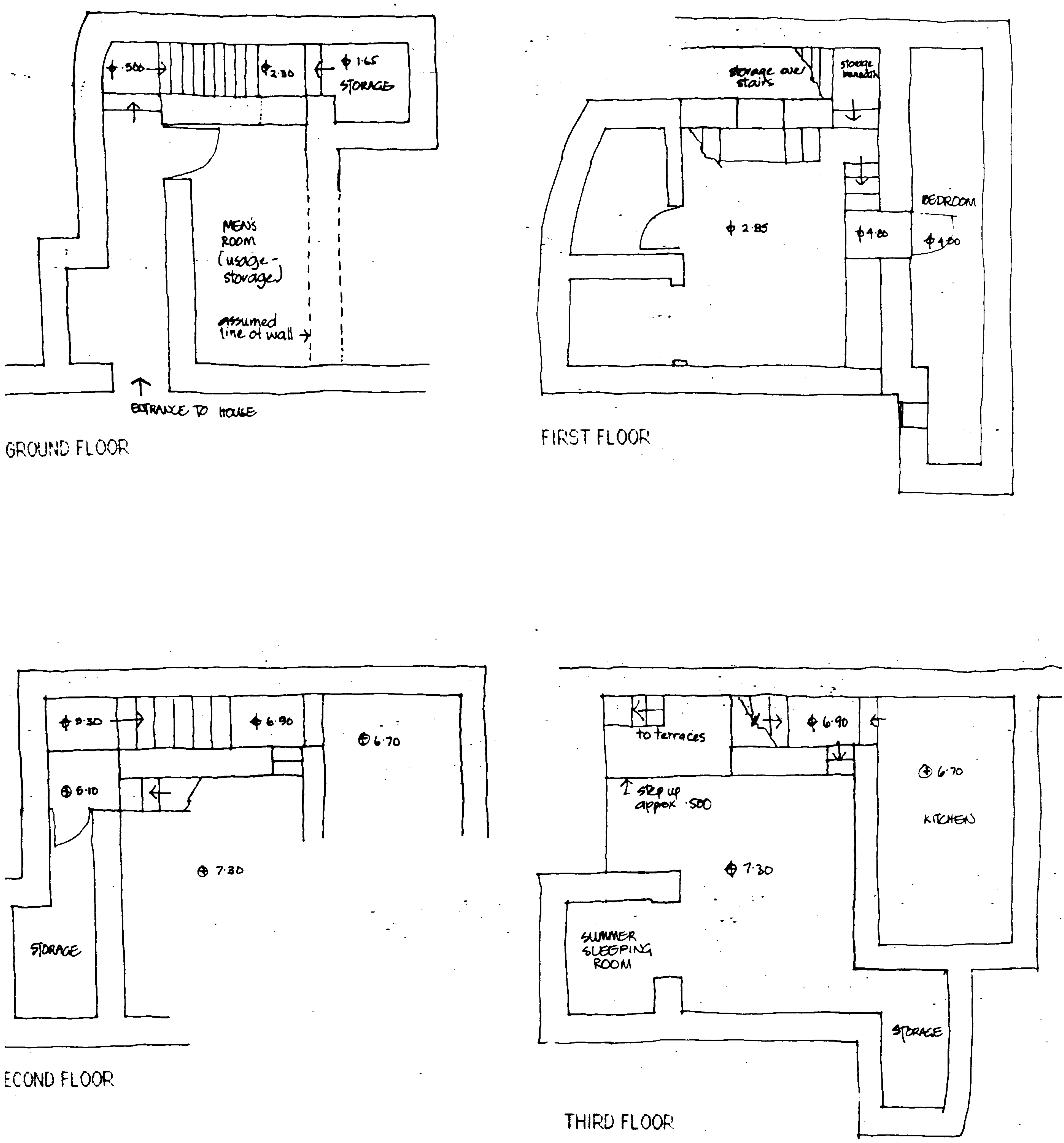


FIG. 2.9: GHADAMES, HOUSE PLAN

the central living room (tamanalt). There is always a bend in these stairs so that, even if the main door and the door of the central living room were both open, one could not look into the central living room from the ground level streets. At the top of the stairs, there is a small landing and off this there is another smaller door leading to the toilet. In most of the visited houses, on this landing there is a recess in the wall which is richly decorated with wall paintings and containing water jars. The toilet is usually a small low ceiling room with a toilet hole in the floor linked to the cess-pool. This is emptied once a year by breaking through one of its walls from the storeroom or directly from the street.

The large central living room constitutes the heart of the house. It is lit by means of a large unglazed skylight situated in the centre of the ceiling (see top floor of House Plan), its walls are richly decorated with painted designs and its floor thickly covered with mats and rugs. Set into the walls are numerous small cupboards closed by means of sculptured and painted wooden doors. The main wall of this room, usually opposite the entrance door from the street, is decorated with suspended ornaments (mirrors, brass trays, brass vases, woven dish covers). Giving off this central living room are two or three other rooms, the most important one from the point of view of the marriage ceremony is called "Alkubba" (see House Plan in fig. 2.9). It is a small room with no windows and its arched entrance is closed simply by means of curtains. It is here that the consummation of the marriage takes place, and it is also here where the wife will mourn her dead husband for three months without setting foot outside the room (Yushea B.Q., 1973, p. 77). In this situation, food and other services (such as bringing the grieving woman water and soap for washing) are provided by her female relatives or neighbours via the roof terraces (Ibid, p. 78). Either on the same side or opposite the "Alkubba" is another room, sometimes windowless but sometimes lit by means of one or more small light-hole giving onto the central room, or into the street by means of a small window giving onto the light-well of the streets at ground level. It is used for sleeping and storage. Along another wall, running for about half its length, is a raised masonry platform, of 1 to 1.5 metres and perhaps 1 metre deep (see House Plan, fig. 2.9), reached by means of several steps at one end. Sometimes, this platform also gives access to another room where all the most precious household belongings are stored. On the other side of the central room to the entrance door from the raised platform, is another staircase leading up to the upper roof terrace. A short distance up this staircase, there is a small door which leads into a fourth room. This is where all the basic food stores are kept, such as wheat, barley, dates and olive oil. This room usually has a small window giving onto the central living room.

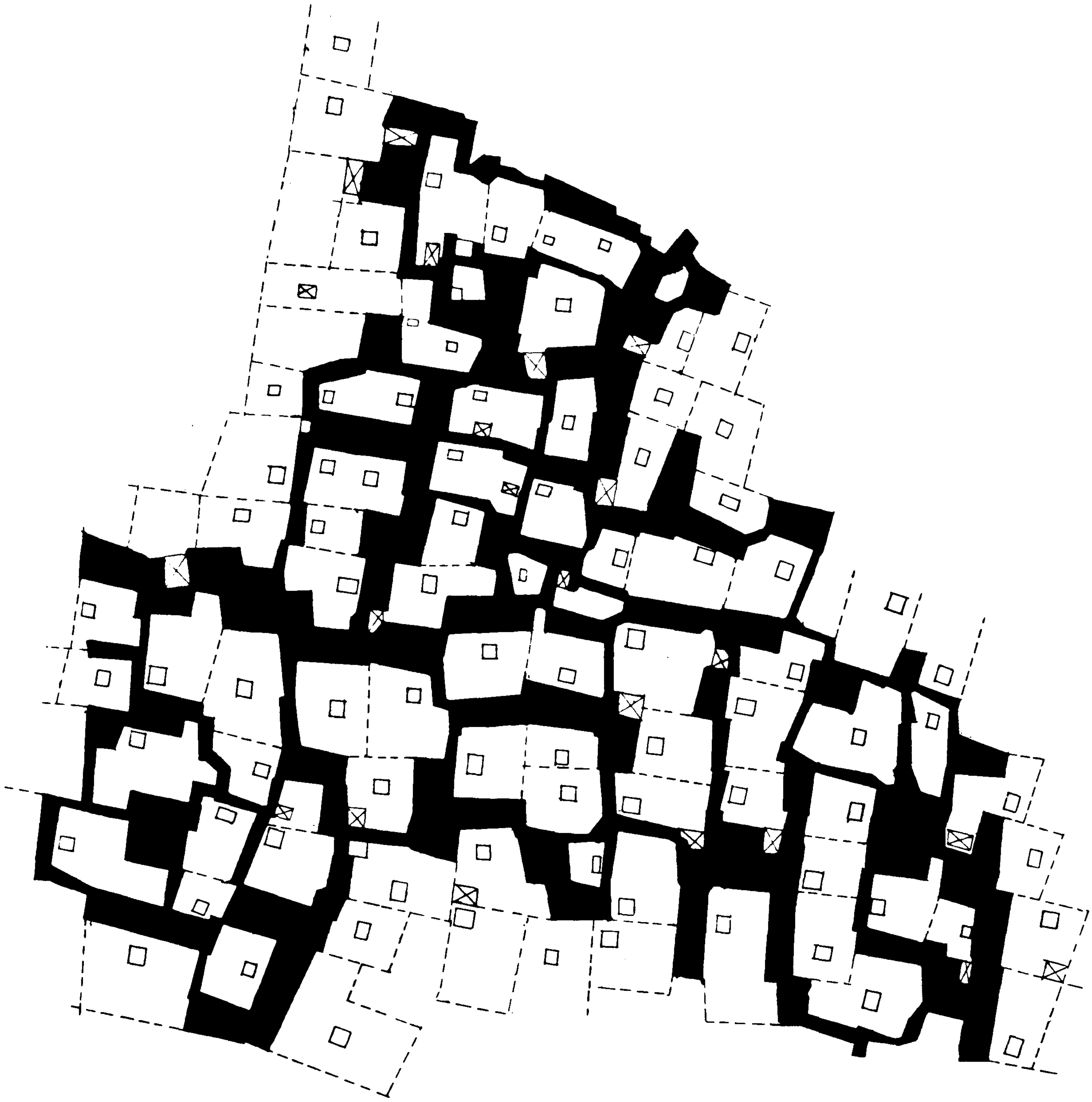
Further up the staircase, which winds its way towards the rooves is situated another storeroom, where a hand-quern (see House Plan, fig. 2.9) is often installed at easy reach to female neighbours who do not have one. Continuing upwards, one reaches another door which obstructs the stairs. These continue beyond the door, now open to the sky, for a short distance until one reaches a small landing, from which one gains access to the kitchen and opposite the kitchen door is the way onto the courtyard roof terrace. The kitchen is fitted with two or three open hearths, several built-in bread ovens, racks for utensils and a smoke-hole in the ceiling.

In the centre of the courtyard roof terrace is the open skylight, protected by an iron grille, which lights the central living room below (see House Plan, fig. 2.9). Giving onto this courtyard terrace are one or two small rooms used for storage and in particular for putting the bedding during the daytime when the entire family (men and women) sleep in the courtyard terrace during the hot summer nights. If there is another room, this is usually very small, and used for keeping chickens and pigeons (tarfu). On the courtyard roof terrace, there is usually a wooden frame consisted of four uprights with a lattice on top, on which vegetables and meat may be placed for drying, or food may be kept cool during the night out of the reach of cats.

A small staircase leads up from the courtyard roof terrace to the upper terraces exclusively used by women.

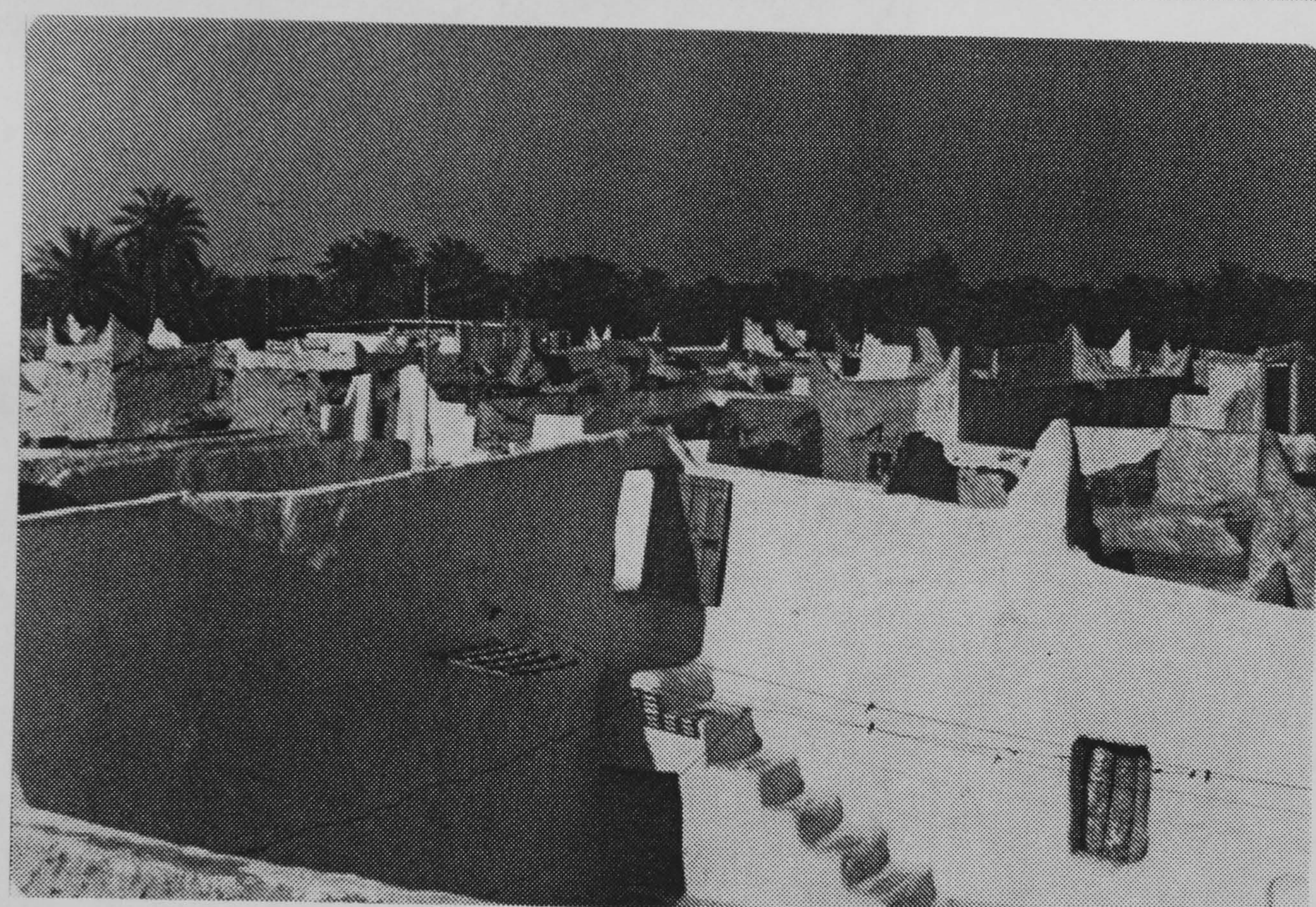
DESCRIPTION OF THE TERRACES:

Figure 2.10 shows the roof plan for the selected area, in which all spaces used for circulation are represented in solid black, and the courtyard roof terraces left in white. The upper terraces are at about 3 metres higher than the level of the upper courtyards, and their access is gained by means of steps. In some cases, the steps and as Picture 11 shows, take the form of veritable staircases. The terraces are made up of narrow pathways, which run along the tops of the partition walls separating the different houses. They are not wide enough to allow two people to pass abreast (see Pictures Nos 10 to 15), but every few metres they widen out onto the upper terraces, which may be either on the roof of the kitchen or on one of the other small rooms that are situated around the perimeter of the courtyard roof terrace or on both. The plan in figure 2.11 shows the complexity of the terraces' configuration. From the surveyed house, one gains access to the roof which is bound by a wall of 0.40 metre high. This roof is connected on two sides by the narrow footpaths, one of which takes the form of a small street (see Picture No. 16), 6 metres long and only 0.65 metre wide. In some cases, a house can be fully surrounded by walkways. These spaces, the narrow pathways and the wider upper roof terraces, link together to form a very com-



Walkway at terraces
Limits of houses
Skylight
Light shaft for streets below at ground floor

FIG. 2.10: GHADAMES, ROOF PLAN



PICTURES 10 TO 12: GHADAMES, WALKWAYS AT ROOFTOP LEVEL

PICTURES 13 TO 15: GHADAMES, WALKWAYS AT ROOFTOP LEVEL

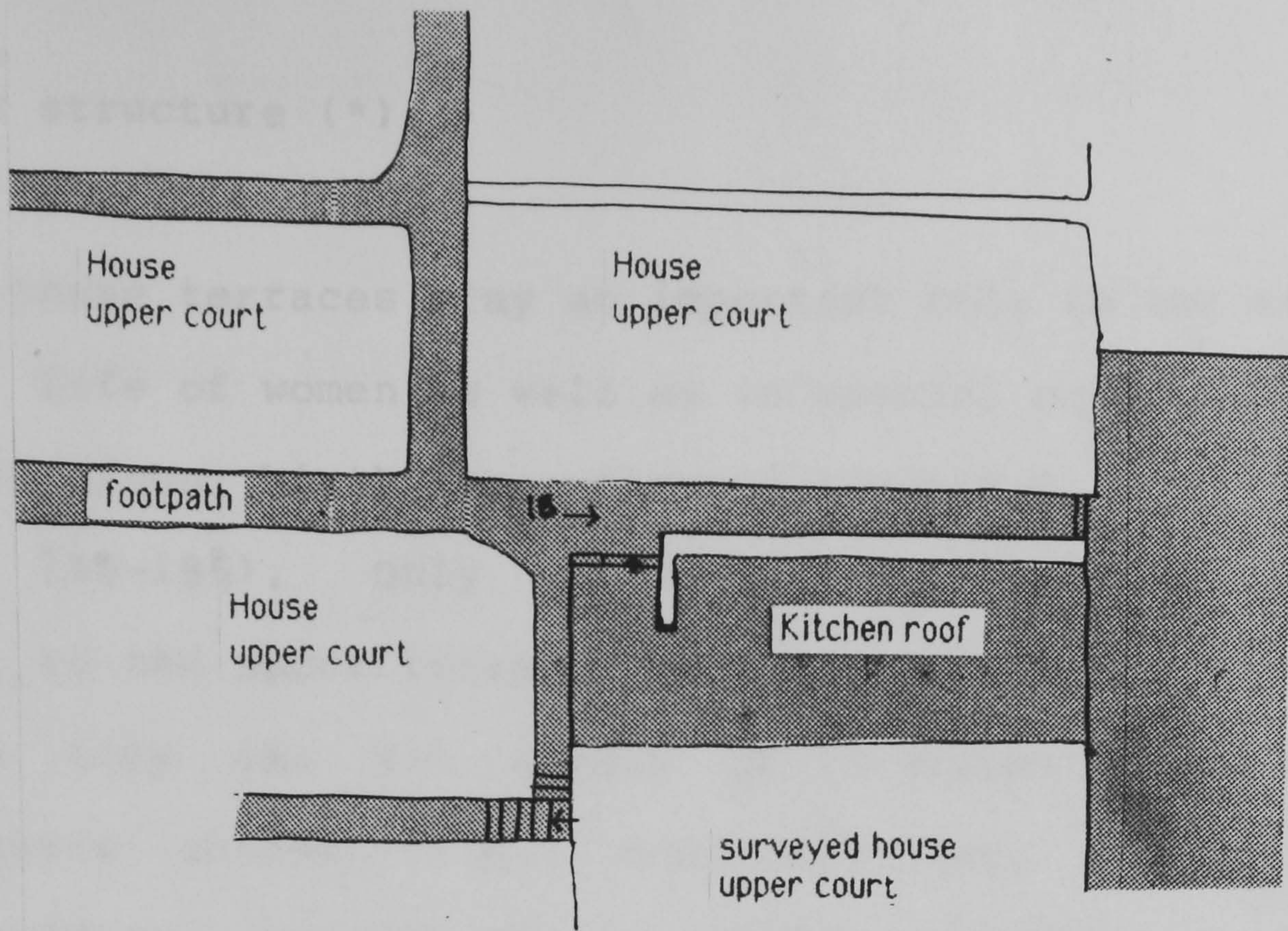


FIG. 2.11 : GHADAMES, ROOF PLAN FOR A SEPARATE HOUSE

Roof area for women's circulation

16→ see Picture 16

PICTURE 16 : A SMALL "STREET" AT ROOFTOP plex structure (*).

All these terraces play an important role in the every-day life of women as well as in special occasions such as weddings, birth announcements (Yushea B. Q., 1973, pp. 186-196). Only the women have access during the day, to the upper terraces and their footpaths, and here they can sit singly or in groups, doing their domestic chores (i.e., wool spinning, sewing and embroidery, cleaning the corn before grinding it, etc.) or simply talking as shown in Picture No. 10.

Men may go there only once a year, on the morning of the feast of "Aid Al-Adha" in order to look at each other's sacrificial animals, which are slaughtered on the courtyard roof terrace, and to check whether any repairs need to be carried out to the roofs and the pathways. During this whole morning, the women will remain below in the houses (Yushea B. Q., 1973, p. 83). The women can of course also use the ground level streets, but then they must be veiled and in practice, it is mainly the old women, who are frail and can no longer safely use the narrow paths who do this.

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* It is extremely difficult to know where one is on the rooves. I asked one of the girls if she can indicate where her house is from the rocfs . She pointed to the irregular pattern of the rooves and walls, and said: "Mabruka lives in front there, Um El Kheir lives in that house beyond that large roof area, and further on, where that curved wall is in the direction of the mosque, that is where I live".

CASE STUDY TWO AND THREE: THE MZAB TOWNS, GHARDAIA AND BENI ISGUEN

THE GEOGRAPHICAL CONTEXT:

Chebka, the Arabic word for net, is used to describe the Mzab region of the Sahara at 600 km south of Algiers, capital of Algeria. The hostile "chebka" is sited on an eroded plateau called "Hamada" (see Location Map in fig. 2.1, p. 27). In the heart of this region, the Mzab river traces a dry course through its valley, rising once in about two or three years after exceptional rainfall. Rain falls on an average of ten days a year and in the hottest months, temperatures reach a maximum of about 46 degrees centigrade. The minimum temperature registered is about 2 degrees centigrade (Station de Meteorologie de Ghardaia).

HISTORICAL AND ECONOMIC BACKGROUND:

A thousand years ago this valley, avoided even by nomadic tribes, because of its lifelessness, was chosen by the Ibadhites as the site for their new settlements (Etherton D., 1971, p. 186).

The "Ibadhites" belong to an Islamic sect similar to the "Kharijism" (in Arabic kharij means dissenter). This schism emerged in the 7th century and had as origin the Prophet's succession (i.e., Addoun A.D., 1977, p. 85). Ali, the Prophet's cousin and son-in-law was proclaimed as the fourth Khalif. During this succession, Mouawia, governor of Syria, pretending also to Khalifat, declared war against Ali. During the battle of Ciffin in 657, in order to avoid bloodshed, Ali accepted Mouawia's proposition which consisted of the submission of the case of succession to some chosen judges (Ibid, p. 87). Here, some of Ali's partisans refused this proposition in the name of the orthodoxy of the Qoranic law which states that "The judgement belongs only to God..." (Ibid, p. 87). These partisans formed therefore the "Kharijit" sect.

Many versions exist in the historic literature on the origin of this dissension, but the most popular is linked with the Prophet's succession. For example, some historians argue that the Ibadhite sect existed well before the conflict between Ali and Mouawia, and assign its origin to the death of the Prophet. At that period twenty one main tendencies arose; some of the Muslims proclaimed that the "Khalifat" (the Prophet's succession) should legitimately belong and remain in the hands of his lineage - Ali for example. Others sustained a democratic tendency, which considers that every man may be elected Khalif by the community (i.e. Addoun A.D., 1977, pp. 85-88). This may have resulted in the first split of the Ibadhites from the other Muslims. However, this divergence may not be the real reason for the emergence of this specific sect, largely because, according to Ibn Khaldun, the "Immamat in the Rostomid state", which was Ibadhite, lasted through many generations in the hands of one lineage: Ibn Rustom' affiliation (Ibn Khaldun, trans. De Slane, 1856 and 1934, pp. 126-140).

Whatever the nature of the conflict, it ended by a dissension and constitution of the Ibadhite sect. Since then, the Ibadhites suffered from a long persecution by other Muslims (Addoun A.D., 1977, p. 87). They were first expelled during the 8th century from Iraq. Ibn Rustom, their leader, founded the kingdom of Tahert, the first Ibadhite settlement in Algeria. This Rustomide state flourished quickly and lasted for more than a century and a half. Tahert, the capital was destroyed after the Chiit Fatemide aggression in 909, and the Ibadhites fled to Wargla (i.e. Donnadieu and Didillon, 1977, p. 29). Sedrata was built nearby as the first new Ibadhite town in the Sahara. It was well sited for trade and quickly attracted other persecutors. Sedrata was destroyed in 1075 (Ibid, p. 32). Hence, the doctrine ceased to play a historical role in Algeria and is only represented by a few communities in the Mzab valley (Ibid, p.33).

Until 1878, no stranger had set foot in a Mzab town, and even today, visitors to Beni Isguen must leave before sunset (Donnadieu and Didillon, 1977, p. 56; Etherton D., 1971, p. 187).

The survival of the Mzab cities and the expensive upkeep of the oases is mainly dependent upon temporary and regular emigration to the north of the male population, working there mainly as shopkeepers (i.e.

Etherton D., 1971, p. 187). The migrants sent money home where it was invested in land, palm groves and houses. As the capital and chief market, Ghardaia progressively enlarged its horizons and became integrated into the saharan commercial network and eventually established itself as a major transit centre. The Mzab has recently benefited from the exploitation of petroleum resources in the neighbouring areas, which were opened up to development just when there was a serious crisis in nomadism. In addition to income brought back through emigration, numerous local commercial activities have recently prospered. In Ghardaia only, around four hundred business entreprises may be counted, and over seven hundred in the whole valley. This figure represents approximately one for every fifty inhabitants. With its 1500 businesses employing 6000 heads of families, this society has maintained a preponderant place in the commerce of the Sahara. Moreover, 5000 of the commercial establishments located throughout the whole country and employing about 20.000 persons are owned by these people (National Census, 1976).

For a long time the Mzab valley remained stable but now it is facing demographic growth, economic modernization and changing way of life. The population of the five towns continue to increase. They now total more than 60.000 inhabitants of which about 35.000 live in Ghardaia and 12.000 in Beni Isguen (National Census, 1976).

The whole valley has about 200.000 palm trees grouped in separate plantations near each town. Within each palm grove, less dense residential districts were built. At the hottest time of the year, it is the custom for most of the population to leave the towns and move to the summer residences. Shaded with apricot, pomegranate and palm trees, the streets and houses of the summer quarters are cool and provide accommodation for about five months. In the plantations, agriculture is practised at three levels. On the ground, the soil is reserved for crops and vegetables. The second level is the fruit trees and the third level is the date palm tree.

Nearby each town, vast spaces are occupied by or reserved for cemeteries. For religious reasons, these spaces are inalienable; and this fact has prevented the growth of the towns in the direction of these sacred areas.

Availability of water is a prime determining factor for settlement since agriculture and human beings require sufficient supplies of fresh water. In areas where the average annual rainfall is regularly less than 100mm, water must be obtained below the surface of the ground. The most important water table of the Sahara, the Albien, is located in the permeable sandstone of the continental intercalcaire.

The water from this underground water table supplies more than 3000 wells. It is distributed among the oases and the individual gardens by a network of irrigation channels, the width of each channel being apportioned to the size of the family and garden. The distribution of water to the individual houses was undertaken by professional porters (Donnadieu and Didillon, 1977, p. 45).

THE SOCIO-POLITICAL AND RELIGIOUS STRUCTURES IN THE MZAB:

Much of the ensuing was derived from the work of Bourdieu "Sociologie de l'Algerie", and Addoun's "Sociologie et Histoire des Ibadhites" (Bourdieu P., 1958, pp. 43-58; Addoun A.D., 1977, pp. 19-56). These social structures refer mainly to the traditional ones, and the question of their importance in everyday lifestyle and social relations remains open. At the present time, the Mzab towns are integrated within the National administrative and institutional system.

The extended family: The basic indivisible component is a group of persons of the same name, descended to the fourth or fifth generation from a common male ancestor. The extended family is a kin-based unit of production and consumption. Men generally practice the same trade and work together. The goods of the extended family are joint possessions and are intended for individual use but not for individual ownership (Bourdieu P., 1958, p. 48).

The Clan: Such institution groups together several male members of the extended families. Generally a clan has its own cemetery named after the ancestor, worshipped every year by a ceremony grouping the whole members of the clan. One member (a man) of each extended family represents his "unit" at the council of the clan, which takes care of the common interests such as collective work, drawing water, destiny of widows and adoption of orphans, protection of the old and organisation of festivities, inflicting of punishment or penalties. For instance, in Ghardaia there are two clans: the Ouled Ammi Aissa and the Ouled Ba Sliman. Beni Isguen has three clans, one of them is named Ouled Anan (Ibid, p. 48). There is no evidence that the clans have any spatial reference points.

The Soff: Within the towns of the Mzab, the different clans are grouped into two soffs: the soff Chergui, the Eastern soff and the soff Gherbi, the Western soff (Donnadieu and Didillon, 1977, p. 56). These soffs are not kin-based nor spatially defined units and may be compared to political parties. Each family could adhere to the one or the other soff according to its options with the possibility of change. But in any case there is no individual adhesion. Each soff struggles for supremacy. Frequently, these fights have provoked civil war, which sometimes ended by a complete exclusion of a soff. It might be so that Berriane and Guerrara, two other Ibadhite towns at 10 kilometres away from Ghardaia, came into existence (Bourdieu P., 1958, pp. 47-48).

The Djemaa: Each "clan" elects its own "Mokkadem" to represent it, and these men together form the "djemaa" of the city. The city council for Ghardaia, "the djemaa", would formally meet at the "haouita", an open area situated at the market place and whose boundaries are demarcated by twenty-six stones collected from specific tombs (Mercier M., 1923, p. 87). This council designates among its members a chief called the "hakem" and his "naib", the "vice-hakem" (Bourdieu P., 1958, pp. 48-49). Normally the Naib is chosen from the soff opposite to the one to which the "Hakem" belongs. The Djemaa takes care of the problems of the whole community, such as the construction and maintenance of public facilities (i.e. irrigation systems, the mosque, the school etc.), penalties, town festivities. The Djemaa has a police, town guards under its orders (Ibid, p. 49).

In parallel to this secular organisation, a religious one exists as well. The clergy or "tolba" represent the spiritual elite of the town; they are divided into two groups: the major clergy, the "sheikh", and the minor clergy (Ibid. p. 48; Morand M., 1910, pp. 419-453). The minors take care of teaching the Qoran to the young pupils. They can accede to the rank of sheikh and even to "Azzab" which is the highest person in this religious hierarchy.

For all questions of importance, the "secular" and the "religious" meet at the mosque in the presence of the "Halqua", a council constituted of twelve representatives of the major clergymen, directed by the sheikh Baba, chosen among them to be the local religious leader. Each member of the "Halqua" is attributed a particular responsibility. The "Muedden" calls for prayer, the "Imam" directs it, some of them are in charge with the education of the children, others with burial rites. The "Qadi" has the task of judgment, which is based both on the Qoran and the Ittifaqatt, the written book of the Mzabite customs and laws (Bourdieu P., 1958, pp. 48-49). The "Halqua" is granted the power of excommunication, "ettebria", the supreme punishment equivalent to a social death of the guilty person (Ibid, p. 49).

This predominantly male organisation, especially the religious one, can be characterised as hierarchical. Only one female group is attached to these institutions. This is called the "Timsiridine" or the "Azzabat", which groups the "matrons" of the town (Addoun A.D., 1977, p. 54). These women are appointed by the town council and their duties are to collect information from women when required, to check their behaviour and pregnancy, and are also in charge of the ritual "bathing" of women corpes, which is considered as the last blessing before burial.

THE STATUS OF WOMEN IN THE MZAB:

The women of the Mzabites are reported to lead a strictly regulated life (Ibid, pp. 35-39).

It is said that the man has complete authority over the women, and the father can force his daughter to marry unless she has previously been divorced (Gordon A.C., 1968, p. 17). Provided a man lodges his wife comfortably and devotes a certain amount of time to her, it is claimed that he can keep her bound to the house. Monogamy is the general rule, although the husband can repudiate a wife and then remarry. Goichon tells a story of a Mzabite leading woman who, taking advantage of the tradition that requires a corpseto be ritually washed by specially designated women, the "Timsiridine", before the body can be considered consecrated, organised the women "washers" into a kind of inquisition (Goichon A.M., 1927, p. 67). Masqueray reports that:

> "It must be recognised that the women are in a real state of inferiority. Islam is the reason. It is the Islam which has put down the African woman. Today, in the Mzab, the clergymen force them to never leave their homes" (Masqueray E., 1879, p. 80).

Donnadieu and Didillon write that the Mzabite society is amongst the strictest concerning the wearing of the veil (*) and the seclusion of the woman (Donnadieu and Didillon, 1977, p. 70).

From these accounts, it becomes clear that the relation between the sexes and the social status of women in these societies is described most consistently and is explained most explicitly within the realm of religion. When the question of male-female relationship is evoked, it is mainly expressed in terms of the "male-superior and female-inferior" paradigm. Islam is seen as male in its most public, most formal organisational aspects.

Islamic laws and traditions are frequently evoked to account for behaviour among Muslims, particularly the behaviour of the sexes (The Qoran, Surah IV, "Annisa", i.e. Women). This may have promoted a far too simplistic but widespread opinion, namely that Muslim women occupy a position of absolute subjugation; that they are completely under the domination of men, controlled within the family by their fathers, brothers, and later in marriage by their husbands. Furthermore, it is believed by many that they have but little knowledge of and no influence on the wider working of their society (i.e., Cromer Lord, 1928, p. 65). They

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* The Mzabite women do not remove their veil in a male presence, not even to take identity photograph for official documents. In fact, they are the only women in Algeria allowed by governmental decree to keep the veil for their passport photographs.

appear to be without a say in public matters, unable to take action in politics, and prevented from doing so in the religious fields, as women cannot hold religious offices. Muslim women are thought of as almost non-existent within the public sphere, kept out of sight in confinement within the protective walls of their homes or "invisible" when heavily veiled, they move outside these.

In most studies on social structures of these towns, emphasis has been mainly placed upon the normative systems, and very little reference has been made to everyday life, nor to the differential uses of the settlement space by the sexes.

DATA GATHERING AND SOURCE MATERIAL:

Several techniques were used in gathering the data for this study. They included an extensive field research conducted in the two towns, Ghardaia and Beni Isguen, as well as a library research. National archives and cartographic institutes in Algiers were consulted for historical records. Several interviews and discussions were held with different persons, men and women.

The primary source material for the Mzab towns has been all the maps drawn at a scale of 1:1000 by "l'Atelier du Mzab" in 1976. These are complemented by the latest aerial photographs of the towns provided by the National Institute of Cartography in Algiers. These documents formed the basis for the site surveys which involved the updating and checking of the ground plans for Ghardaia and Beni Isguen, and a recording of the public buildings and street furniture. Visits to houses were also undertaken, and about 30 house plans at a scale of 1:50 were also provided by the "Atelier du Mzab" in addition to plans of some public buildings such as mosques, market places.

The survey for the terraces was focussed on one area located in the old part of Beni Isguen. A roof plan at a scale of 1:1000 of this area was available at the "Atelier du Mzab" and visits to terraces were possible in Beni Isguen because the author had a local contact in this town. Similar contacts were not possible to establish in Ghardaia, though occasional visits to the rooves were also permitted. The survey consisted mainly at checking the roof plan and recording accesses between separate terraces.

THE MZAB TOWNS: A PERSPECTIVE INTO PAST STUDIES

A review of the existing literature on the Mzab settlements shows the existence of a large amount of material which covers a considerable time span, from 1830 to the present time and ranges from travellers' accounts to more specific studies. But a great deal of these contributions were mainly in the form of broad surveys on historical and social aspects in these settlements (i.e. Huguet Dr, 1906; Bourdieu P., 1958; Merghoub B., 1964; Addoun A. D., 1977). Past studies on these towns have focussed on specific problems ranging from geological explorations (i.e., Ville, 1872) to religious concern of the Ibadhite schism (i.e., Duveyrier H., 1878), to more extensive linguistic and historical issues (i.e., Masqueray E., 1878; Motylinski, 1904; Basset A., 1959; Manouz S., 1968; Aymo J., 1959), to studies on the legislative and jurisdiction structures (i.e., Merghoub B., 1970).

In spite of the considerable knowledge gained over the years on particular aspects of these settlements as the above studies demonstrate, only limited knowledge exists by way of documentation on the specific question concerning the relation between the social and spatial structures of these towns. The understanding of the nature of this relation is greatly limited by the dearth of the literature in this field of research.

Most of the writings on the morphology of the Mzab settlements focussed on descriptive, picturesque and aesthetic aspects. Extensive photographic compendia have been published (i.e. Roche M., 1970; Pavard C., 1980), praising "The moving and many-faceted beauty of these miracle towns which human determination has caused to rise from the desert" (Pavard C., 1980, p. 116).

Other studies regarded these urban forms as unique and extraordinary examples in the history of Architecture, as "une lecon d'architecture" of a planned response to severe climatic conditions and clearly defined social requirements (i.e. Ravereau and Deluz, 1964; Etherton D., 1971, p. 188). On this particular point, M. de Maisonseul suggests that Le Corbusier's work was deeply affected by visits he made to the Mzab in 1935. He points out similarities in the forms of several buildings in Ghardaia and the Chapel of Ronchamp, and observes that Le Corbusier's concern with curved shapes dates from the time of these visits (i.e., Etherton D., 1971, p. 188).

As such this architecture is then seen as a basis from which knowledge can be gained in the aim to improve the design of future buildings and environments. On this matter, N. Saada writes:

> "Knowledge and experience are there for anyone to share and to learn from, standing the local architecture and pattern." (N. Saada, 1977, p. 36)

In the face of this interest, "l'Atelier du Mzab" a development corporation, has been established as a measure to study and safeguard the Valley. Most of the work of the Atelier consisted of extensive site and building surveys in which the output have been a large amount of data (ground plans for the five settlements, listing of the public buildings, house plans...), and much of which has been used in the present research work (*).

Other studies implied a relationship between cultural values, societal regulations and the built environment (i.e. Etherton D., 1971, p. 187; Delaval B., 1974, pp. 252-258). This relationship is described in terms of an almost mechanical effect of some functional factors such as the climate and religion. The main line of thought of these studies has therefore been the belief in prime movers, simple functional determinants of the internal structure of these towns (i.e. Schacht J., 1954, p. 27). Within this framework, religious requirements are for example, seen as the main determinant in dictating and the moulding of space. From religion come the ideals and the norms of social behaviours which is reflected in the structure of the settlements (N. Saada, 1977, p. 36; Donnadieu and Didillon, 1977, p. 43). The lack of decoration, the introverted house structure, the absence of large fenestrations and openings, the street configurations (i.e., the dead-end structure), all these formal characteristics have been interpreted as a result of Islam. In none of these studies however, is any attempt made to explicate the precise mechanism of this alleged cause and effect relation between social order and architecture.

For instance, Burckhart commenting on some functional aspects of this type of Architecture writes:

* Most of the work of the "Atelier du Mzab" has been published by Donnadieu & Didillon, though the project was a team work, financed by the Algerian Ministry of Housing and Construction.

> "It is the Islamic concept of the family, which has more than anything else, determined the form of the dwelling." (Burckhardt T., 1976, p. 169).

But nothing more is said either of the distinctive feature of the Islamic towns or the dualistic feature of the architecture, nor of why one implies the other. A characteristic set of claims has therefore emerged which refers to a relationship between privacy and spatial fabric of these towns. Delaval describes the Mzab towns as

> "extremely well planned buildings with hierarchies of public space from market place to entryways and regulated privacy that amplifies the life in the towns" (Delaval B., 1974, p. 254).

According to Delaval, circulation is handled through, first a system of main access ways which lead to the mosque, marketplace, and gates of the town, next the secondary which handle small shops and access to some houses, and finally the "impasse" on which most of the entrances to houses are located. Moreover, each entrance to a house is always a "chicane" which makes entering a private matter and a ritual. This value of privacy can be extended, according to Delaval, to the forms of dress (Ibid, p. 255). To Delaval, the physical structure of the city is organised according to a tree-pattern, which is an image of the social structure (Ibid, 1974, p. 252). Etherton on his part states that one of the most interesting aspects of the Mzab towns is that a common solution has been found to building for climate and for privacy, anticipating modern theories of how to tailor buildings and urban space (Etherton D., 1971, pp. 187-188).

In fact, the same argument has been extended either explicitly or tacitly, to the description of the roof terrace system that is present in Ghadames and the Mzab settlements. For instance, Donnadieu and Didillon in their description of the roof terraces in the Mzab write:

> "The roof terraces are the most private spaces... Their access is strictly reserved for women... There, they can sit, talk and carry out various domestic chores in complete privacy" (Donnadieu and Didillon, 1977, p. 84).

Within this framework, the terraces appear as a higher instance of the privacy scale.

In principle, what this literature review shows is that many studies imply a relation between the social structures and the settlement form, without really describing it.

THE BUILT ENVIRONMENT:

The physical layout of the valley follows a quite consistent pattern. Five distinct settlements - Ghardaia, Beni Isguen, Bounoura, Melika and El Ateuf- are deployed on high ground. Each of the five towns is made up of similar elements: a "ksar" or the winter settlement, a date-palm plantation with the summer residences, and cemeteries (see fig. 2.12). The five towns are linked together by an elaborate hydraulic system that follows the course of the river. But they are separated and isolated from each other by large, rugged open spaces of the desert. The hydraulic system was the only physical link that existed between the towns. Otherwise, until 1962 (*), they were completely independent of each other (Donnadieu and Didillon, 1977, p.27; Bousquet G. H., 1982, p. 12).

The limits of each of the five settlements are demarcated by a fortified wall. The close texture of streets, ramps and steps is broken only by an open market place. There is no vegetation within the towns. Their location on high ground deliberately leaves the flat area, close to the river for cultivation.

DESCRIPTION OF THE GROUND PLAN OF GHARDAIA:

Ghardaia is the largest and the most important settlement in the valley (see Town Plan in fig. 2.14 and fig. 2.13). It is made up of approximately 5000 houses. It is organised around a hill, the summit of which is occupied by the main mosque (see Picture No. 18). The town was fully surrounded by high walls that are now

* In 1962, Algeria gained independence from France, and the Mzab towns became then incorporated in the National administrative system.

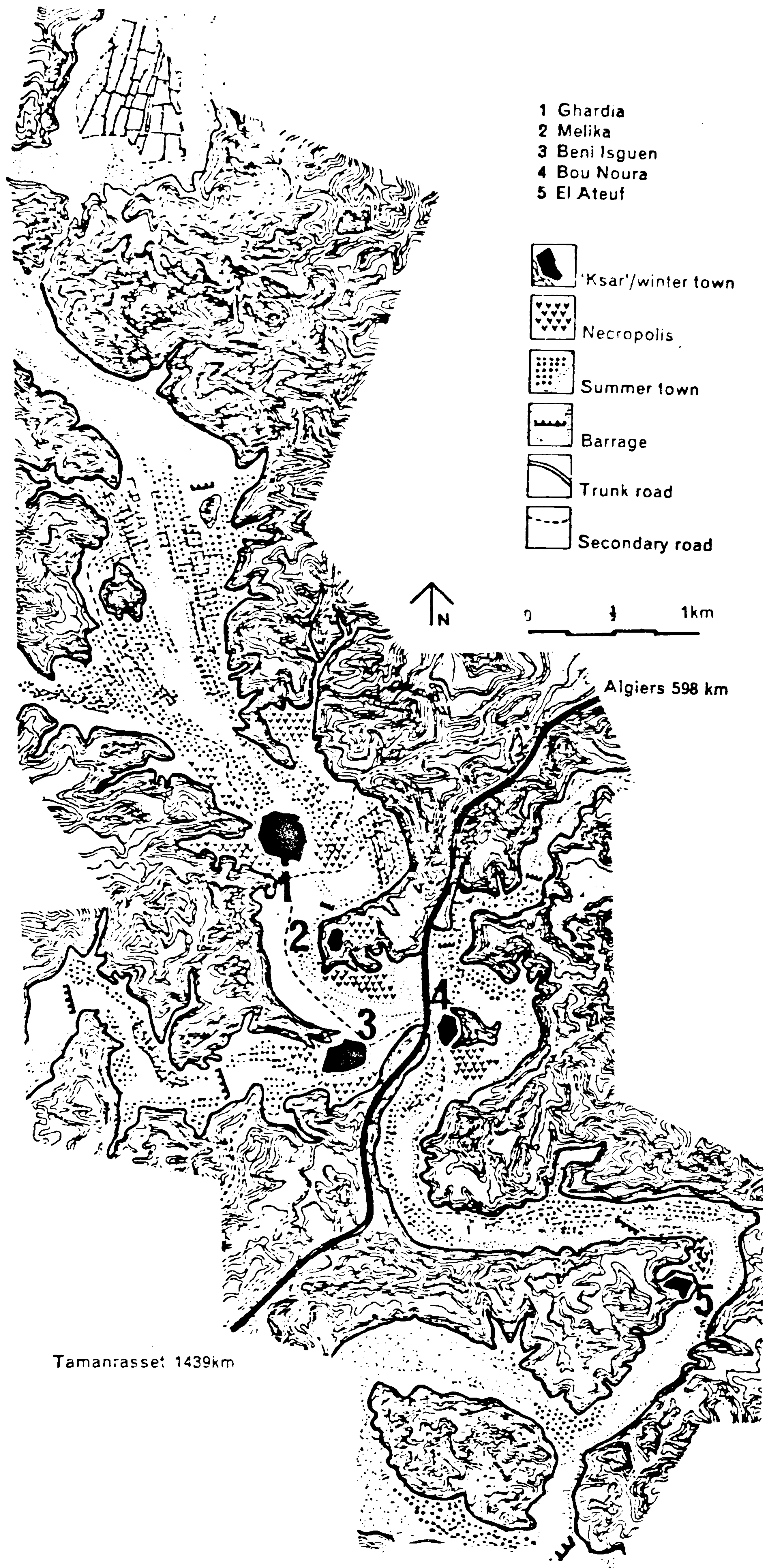
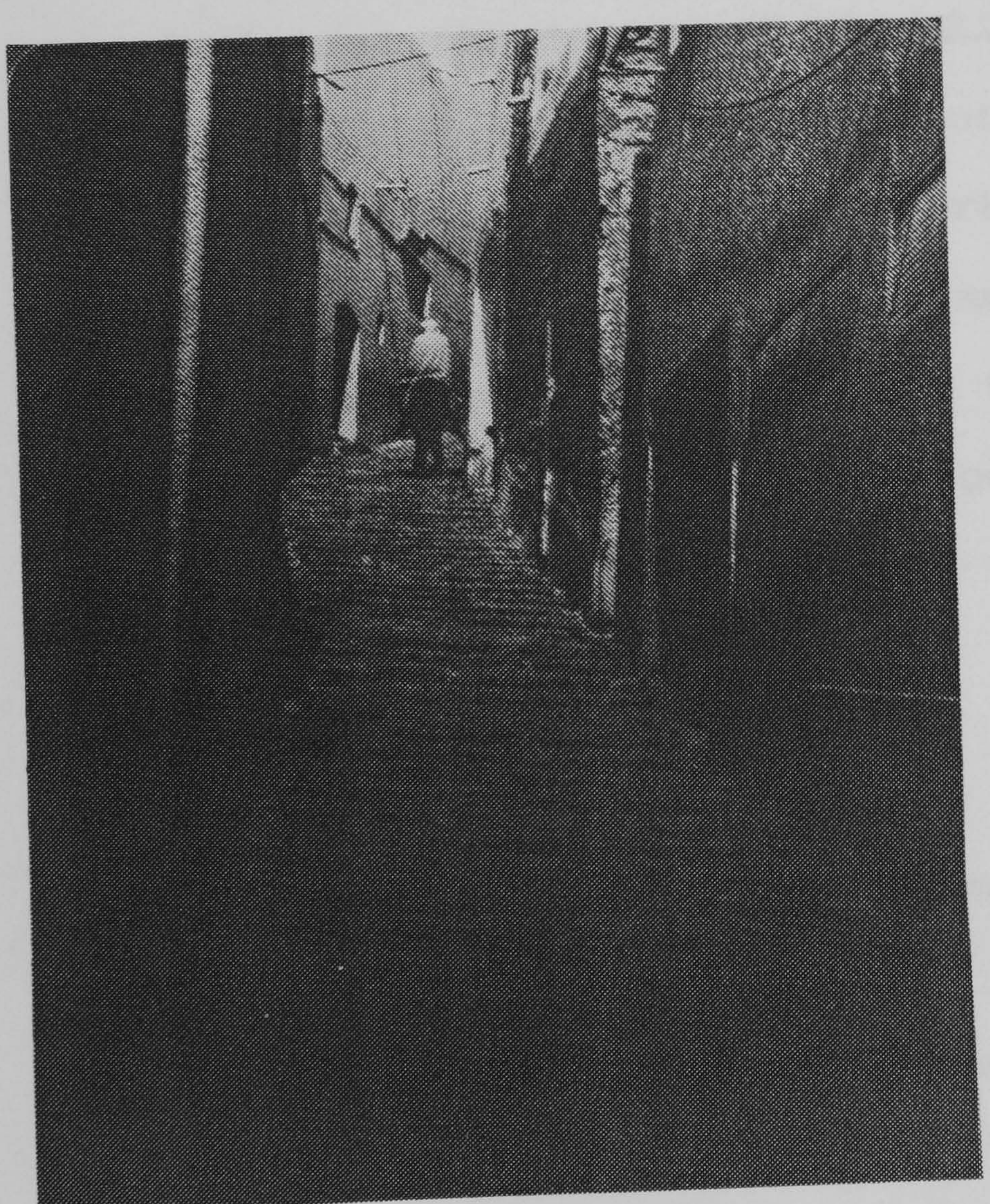


FIG. 2.12 : THE PHYSICAL LAYOUT OF THE VALLEY

FIG. 2.13 : GHARDAIA, AERIAL PHOTOGRAPHY

FIG. 2.14: GHARDAIA, GROUND PLAN

PICTURE 18 : GHARDAIA, GENERAL VIEW



PICTURE 19 : GHARDAIA, STEEP STREET

partly demolished and replaced by a ring road, and the access to it was through seven gateways, four of which from the north-west border. Two gateways link the market square to the outside.

From the aerial view, the townscape appears to be made up of concentric bands of courtyard houses falling away from the central mosque. The urban fabric is made up of large blocks of houses of two to three storey high, densely packed together and separated by narrow and winding alleyways which become more regular in the vicinity of the large market square. These alleys can be less than 2 metres wide and in places, they are true tunnels where an eternal darkness prevails. Owing to the fact that the course of the alley is not marked out before hand and to the great distortion of the contour lines of buildings from the an orthogonal geometry, an erratic network of alleys grows, many of them cul-de-sacs. In some places, the alleys take the form of very steep ramps and in others they become veritable "stair-ways" continuously built without landings (see Picture 19).

The ground plan of the town shows the location of the public facilities, which are mainly religious and commercial in nature. The market of Ghardaia located at the south-west periphery of the town is the most important in the valley, and until the beginning of the century, the caravans brought their products to sell in the weekly market of Friday. Arriving on Thursday, the nomads used to be locked during the night inside the market square (Donnadieu and Didillon, 1977, p. 51).

The market place, which has a rectangular shape, is entirely surrounded by an arcade on which give many shops and boutiques (see Pictures Nos 20, 21). On one side, the auction market takes place. The auctioneers walk around with the goods that are presented to the people seated on the ground. This market square is the site for other minor markets such as the meat market, the vegetable market, clothes, house contents. It is as well the converging point of the commercial streets (see Picture No. 22). These streets especially the "Suq street" which links the market place to the gateway "Bab Djedid", is furnished with masonry benches where men sit in front of their shops. These seats are also built all along the market arcade. Outside this commercial nucleus, very few businesses and shops exist inside the town, except for three boutiques that are located at the "rahbat" place, east of the central mosque, annexed by a medersa which is a school for learning the Qoran (see Ground Plan in fig. 2.14).

A fairly regular street runs uphill from the market square (see Picture No. 19) towards a smaller mosque which marks the original border of the settlement. This mosque was, according to Donnadieu and Didillon, reserved for the Ibadhites of Wargla during their passage in Ghardaia (Donnadieu and Didillon, 1977, p. 50). From this point, the street structure becomes more con-

PICTURES 20, 21: GHARDAIA, THE MARKET SQUARE AND ARCADE

PICTURE 22: GHARDAIA, COMMERCIAL STREET

PICTURE 23 : BENI ISGUEN, A STREET IN THE OLDER PART centric, forming two rings around the summit of the hill. Because of the sharp slope, sections of these streets, particularly those adjoining the central mosque, are made up of two platforms at different level of height and linked to each other through staircases. Other mosques are built nearby the graveyards outside the town walls with large whitewashed areas left open for prayer meetings.

The date-palm plantation and gardens of Ghardaia are situated north-west of the town at about 2 kilometres. In these gardens, summer residences are established together with mosques, shops and schools in order to allow a longer and more comfortable stay during the hot season.

PHASES OF GROWTH OF GHARDAIA:

The plan in figure 2.15, indicates the three different phases of development of Ghardaia. These can be easily identified by the remainings of the walls that once surrounded the initial settlement as well as from the examination of the aerial photography which clearly shows two internal concentric rings (see fig. 2.13). The first nucleus started to grow around the mosque and on a very high ground (Donnadieu and Didillon, 1977, p. 50). However, there is no evidence for thinking that the structure of the oldest parts of the town has or has not changed over time. The location of the original market is unknown, but the market place at the

GHARDAIA AT PHASE ONE

GHARDAIA AT PHASE TWO

GHARDAIA AT PHASE THREE

FIG. 2.15 : GHARDAIA, PHASES OF EXPANSION

second phase of development called "rahbat" is situated away from the main mosque as indicated in the map (Ibid, p. 50).

BENI ISGUEN:

Beni Isguen, the second largest city is also built on a high ground and located at about 2.5 kilometres east of Ghardaia, at the meeting point of the two rivers Ntissa and Mzab. The town is constituted by about 1485 houses, 273 of which give onto cul-de-sacs, occupying an area of approximately 16 hectares. If Ghardaia is known as the commercial city, Beni Isguen is the spiritual or the holy city for the entire valley. The access of the town is through four gateways, which constitute the only entrance points to the town; one to the north called "Bab Chergui", one to the east called "Al Kharajja" (*) and two to the south one of which is called "Bab Gherbi" (see Town Map in fig. 2.17). The town walls or ramparts are accompanied by several watchtowers, the most dominant one being the tower of "Sheikh Ba El Hajj". The streets in the upper part of Beni Isguen are steep and very winding (see Picture No. 23, p. 91), but in the more recent and lower part of the town, the street network becomes more regular (see Aerial Photo in fig. 2.16, and Town Plan in fig. 2.17). The main mosque, in this case as well, occupies the top

* The gateway called "Al Kharajja" or the "exit gate", is used for the funeral procession. A dead person is "taken out" of the town through this gateway to the burial ground.

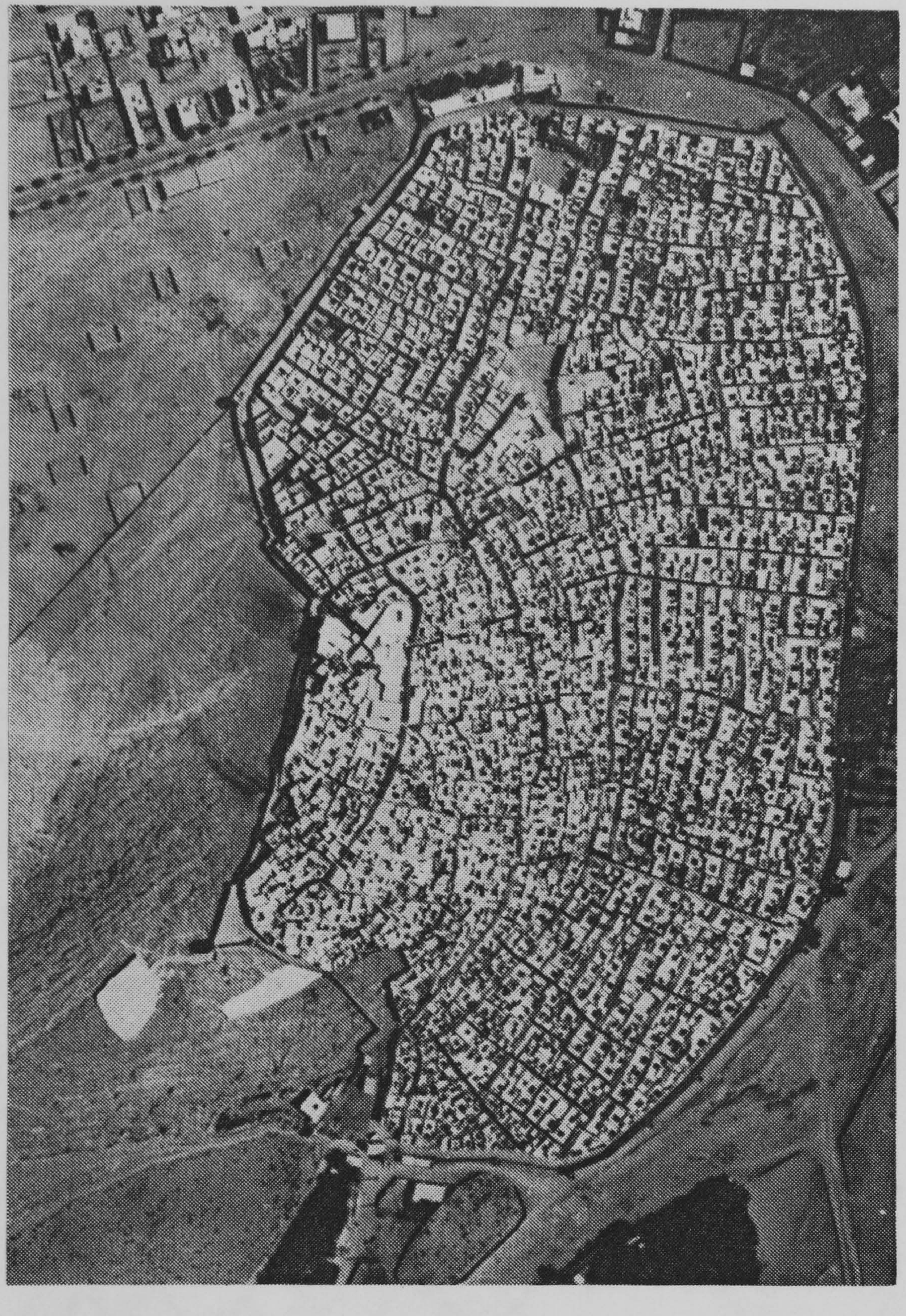


FIG. 2.16 : BENI ISGUEN, AERIAL PHOTOGRAPHY

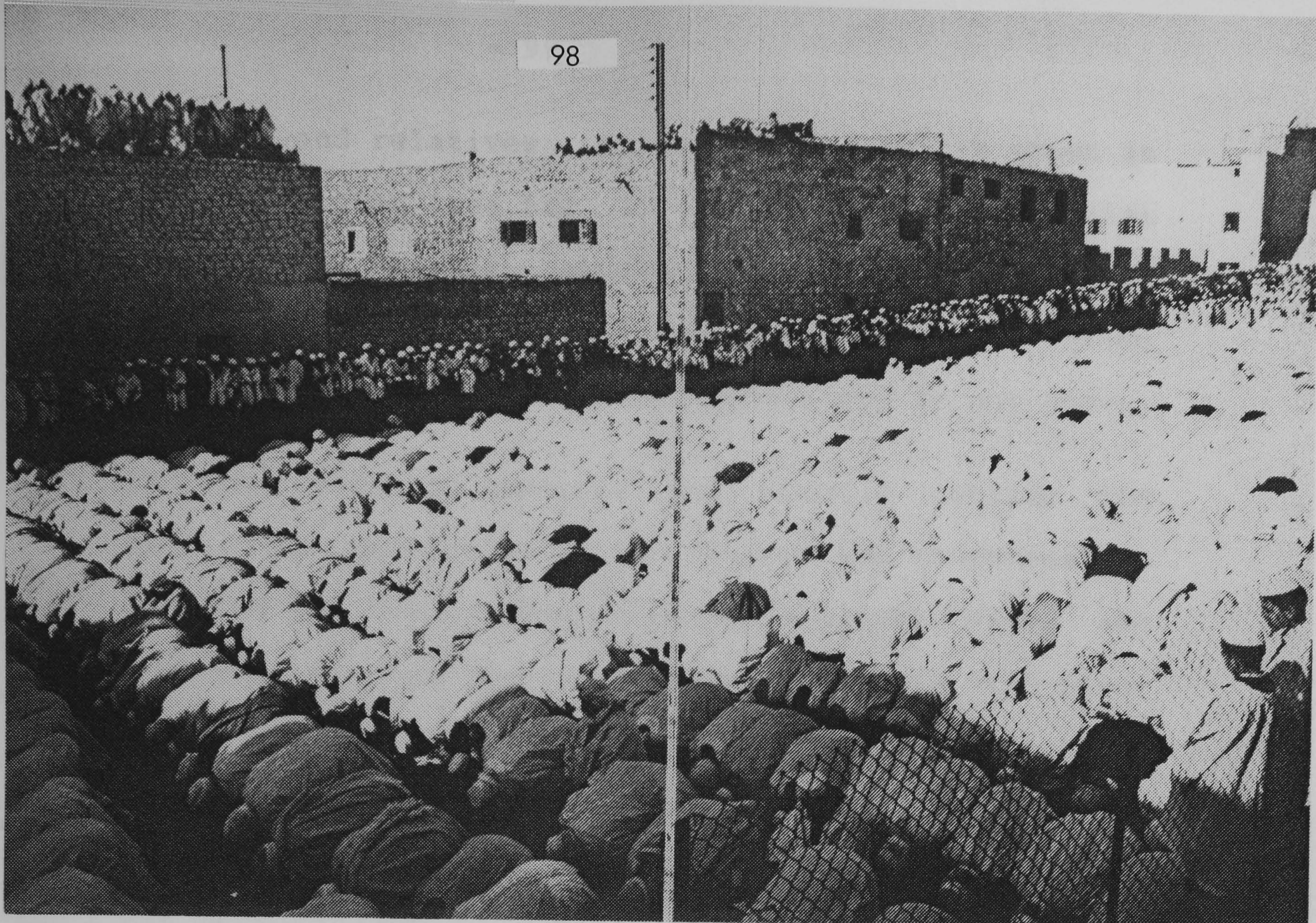
	Streets, alleys
	Cul-de-sac
	Ramp
	Cemetery
H2	Surveyed houses
AP	Prayer area
24	see picture 24
	Area covered by roof survey

FIG. 2.17: BENI ISGUEN, GROUND PLAN

of the hill, not far away from the north-eastern border of the walls (see Town Plan in fig. 2.17).

In addition to the main mosque and its adjacent Qoranic schools and zaouia (religious lodges), two other religious buildings exist in this town. These are the ancient mosque "Tafilalt" which is mainly reserved for women's use (Donnadieu and Didillon, 1977, pp. 56-58), and the praying area "Boudjira" located near the gateway "Bab Chergui" and close to the Timsiridine's house (the "clergywomen"; see Picture No. 24). This area is mainly used by men who come to read the "Fatiha", the first verse of the Qoran, during the departure of a member of the family for immigration or pilgrimage to Makkah. One part of this area with a separate entrance is reserved for women meeting.

The market place of a triangular shape is partially surrounded by shops and boutiques. The market is quite famous for its daily auctions, which usually take place between the afternoon and the evening prayers. The market place is furnished with masonry benches built around it (see Picture No. 25) and in its centre is located a well. Everyday, the same people occupy the same seats and any absence or change of seating place has a meaning, i.e. anger towards a person can be expressed by not sitting near that person (Donnadieu and Didillon, 1977, p. 59). The market is not only a place where transactions and exchanges take place, but also the centre for information, a meeting place for



PICTURE 24 : BENI ISGUEN, PRAYING AREA (BOUDJIRA)

PICTURE 25 : BENI ISGUEN, THE MARKET PLACE friends and relatives. As in Ghardaia and as shown in the Ground Plan (see fig. 2.17), very few shops exist outside the market, but some houses are used as shops exclusively serviced by and reserved for women (Ibid, p. 61). The location of these house-shops is not known.

The cemeteries are numerous and located outside the walls, in particular at the western and south-eastern sides of the town. Mosques and open prayer areas are numerous in these burial grounds. The palm tree plantations of Beni Isguen expand linearly along the river bed of Ntissa and comprise many hydraulic constructions (barrages), notably a large water dam built to collect the storm water. Summer residences are scattered inside the plantations.

PHASES OF DEVELOPMENT OF BENI ISGUEN:

Two phases of development prior to the existing town, are reported in the literature (Donnadieu and Didillon, 1977, p.55; Bousquet G. H., 1982, p.11). As indicated in the map in figure 2.18, the first settlement named "Tafilalt" was built on the upper part of the hill. A mosque, the market site as well as the old gateways are still reminiscent of the old city. During the first stage, the mosque and the market directly connected to each other by a more or less straight street, occupied the central position of the old town. But during the second phase, the market has been shifted to the northern side of the city, and in 1860,

BENI ISGUEN AT PHASE ONE

BENI ISGUEN AT PHASE TWO

BENI ISGUEN WITHIN THE WALLS

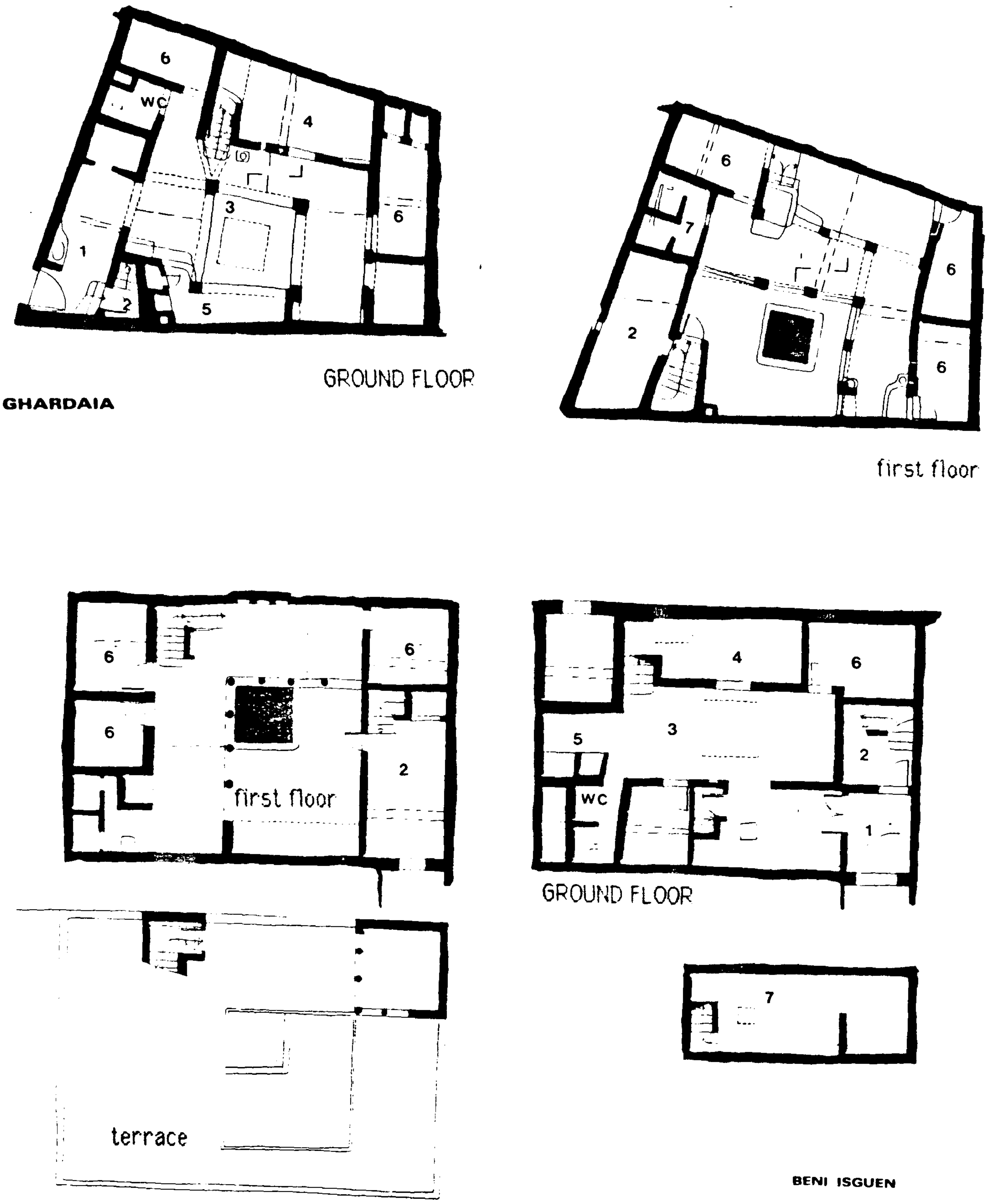
FIG. 2.18 : BENI ISGUEN, PHASES OF EXPANSION

the last town walls were completed (Ibid, p. 55 and p. 11). These are four to five meters high and are regularly maintained by the local population. In this case also, there is no evidence on how far the structure of the old parts of the town has been preserved unchanged over time.

GENERAL DESCRIPTION OF HOUSES IN THE MZAB:

The description of houses is based on the examination of about 20 houses taken from different parts of Ghardaia and Beni Isguen as indicated in the ground plans. These houses have been also analysed syntactically but the results of the analysis have not been included in the present report. Only a small sample of plans have been inserted in this report.

The houses in Ghardaia and Beni Isguen are usually two to three storey buildings, and are invariably built around a courtyard (see House Plans in fig. 2.19). The access from the street to the houses is always through a "dog-leg" passage, locally named "skiffa", which plays an important role in the functioning of the house. The location of the openings in this hall is such that even if the main door of the house is left ajar, one could not look into the central courtyard from the street. On one side of this entrance hall, there is a room used for keeping the domestic animals (i.e. goats, donkey). Sometimes in this chicane, there is a recess in the wall in which a hand-quern is usu-



1 entrance hall (skiffa)
2 living room for men
3 court
4 living room for women
5 kitchen
6 bedroom/storeroom
7 basement

FIG. 2.19 : HOUSE PLANS

ally kept at easy access to the female neighbours who do not have one (Donnadieu and Didillon, 1977, p.75). Also, water jars used to be kept in this space so that the professional water porters could deliver water to the individual houses without exposing the women to their presence . On most of the visited houses, two separate pathways exist to the interiors. The first, or the family path, leads to a courtyard which consists of a large living space surrounded by small rooms. It is there where the main female activities take place. A staircase links the ground floor to the first floor, consisting of bedrooms, arcades and store rooms. Another staircase links the last floor to the rooftops.

The second staircase leads up from the chicane to the separate quarter reserved for the male visitors. These consist of one large room used as the male reception room, with usually a small window giving onto the street. Sometimes, this male reception room which is very richly furnished and decorated is annexed by a bedroom.

The central courtyard is the largest space in the house. It is lit by means of a large skylight situated in the centre of the ceiling and protected by an iron grille. No window gives onto the outside. In summer, this only source of light is covered during the day as a measure of protection against the burning hot sun. No furniture exists in the central courtyard, except for the loom and the built-in shelves for the cooking utensils and an oven which occupies one side of it. In most houses, another kitchen exists at the terraces. The "Tisefri" or the women's living room gives onto the central court. It is used for female visitors and it is in this room where the women move after giving birth. In one corner of this room, there is a raised masonry bench of about 2x2 metres, for women's prayer. The other rooms that give onto the courtyard do not have a specific usage. They are used sometimes as bed-rooms, storage or changing room. The toilet is usually located in a remote corner of the central court. It is dark and a very low-ceiling room with a hole in the floor, connected to the cesspool accessible from the outside by breaking through the exterior wall. The house is equipped as well with a traditional bathroom. From the central courtyard, a staircase leads to the upper floor which consists of the upper courtyard surrounded by small rooms for various uses, and an arcade used by the whole family for sleeping during summer. It is here where the women do their washing, sometimes cooking or take their afternoon coffee alone or with their female visitors (Donnadieu and Didillon, 1977, pp. 83-84). Donnadieu and Didillon write:

> " Of eminent importance in a house is the roof terrace, the domain par excellence of women (Ibid, p. 84).

Another staircase leads up from the upper court to the rooftops which access is exclusively reserved for women. Exceptionally, a man may have access to it, (i.e. to repair a leaking roof), in this case, he must notify the women of his presence by repeating three times a specific "scream", so that the women retreat to the inside (Ibid, p. 84).

DESCRIPTION OF TERRACES IN GHARDAIA AND BENI ISGUEN:

i- GHARDAIA

A bird's eye view of the town (see Pictures 26, 27), gives the impression of a massive building, constituted by several storeys with terraces sloping down from the central and dominating minaret of the mosque.

No overall roof plan exists and visits to the terraces were restricted. Therefore, the following description, which is mainly derived from the examination of photographs, roof plans of individual houses and a few visits, remains limited and the information drawn from it insufficient for establishing a viable basis for an analysis.

The examination of the roof plans for separate houses (about 10 houses) in figure 2.20 suggests a consistent structure underlying the terraces configuration. The first floor of the 10 houses is constituted by small rooms (i.e. kitchen, toilet, storeroom) and an arcade used by the whole family for sleeping during summer. The proportion of the arcade space with respect to the rooms seems to vary from one house to another, and so

PICTURES 26, 27 : GHARDAIA, VIEWS OF ROOF

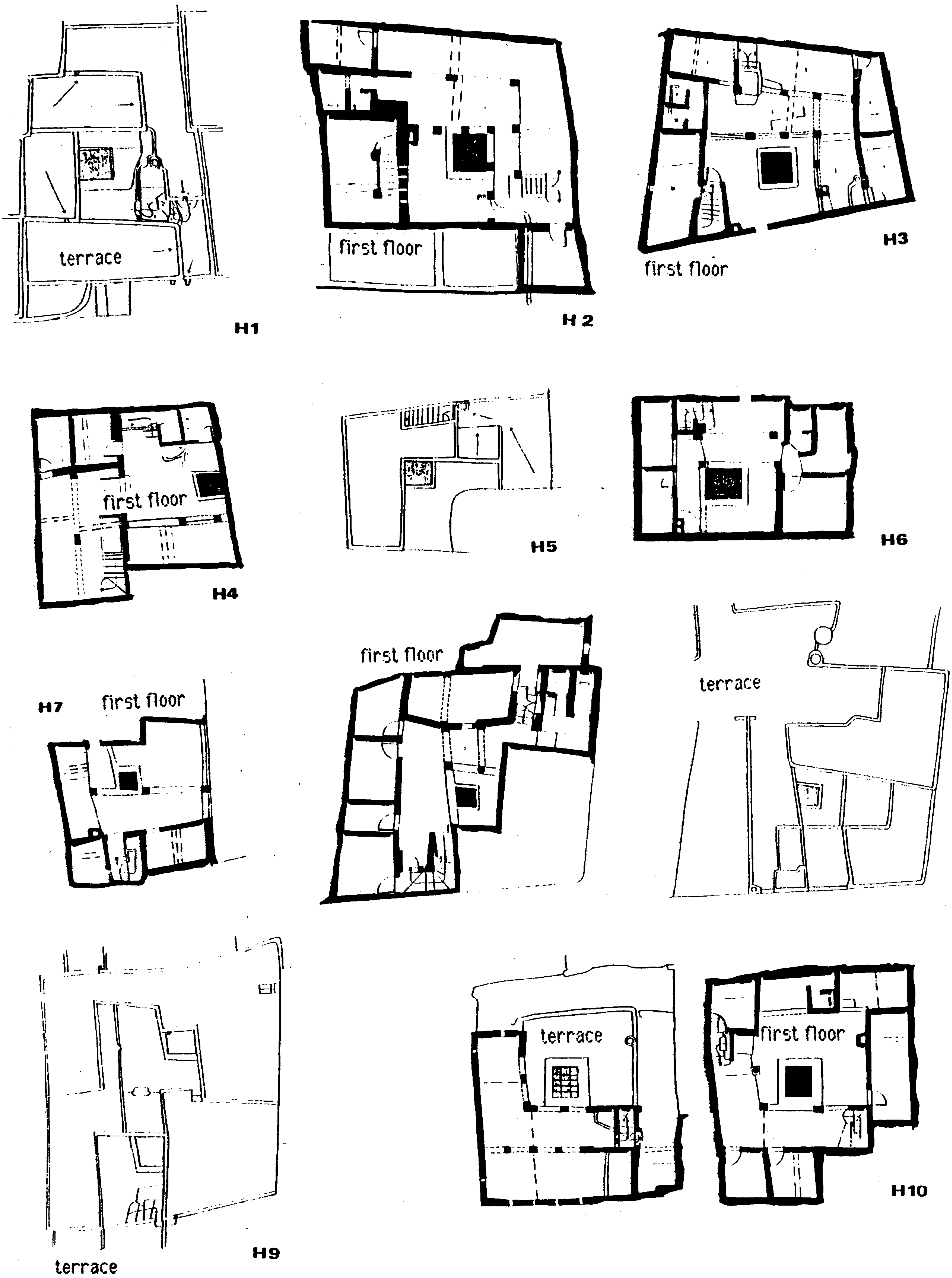


FIG. 2.20 : GHARDAIA, ROOF PLANS FOR SEPARATE HOUSES

does their disposition around the perimeter of the upper court. But, the resulting pattern of the terraces seems to be constituted by a roof area of varying shape directly accessible from the first floor by means of a staircase or a ladder, and the void of the upper courtyard.

In many instances, the disposition of houses in tiers rising up a steep slope, provides each resident with a flat terrace area above the roof of the house immediately below. This is clearly visible on Picture No. 27. The limits of the individual houses seem to be difficult to distinguish, and in some cases, the ~~rooves~~ roofs of the rooms belonging to separate houses link together and form a continuous flat surface.

Almost every roof area is used either frequently, when directly accessible, or occasionally by the women, and the difference of level between the rooves and between the houses by implication is usually overcome by the use of ladders (*). The roof areas used by women when moving about are not clearly defined by physical boundaries and seem to take place wherever it is possible.

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* Most of the houses are equipped with a ladder stored at the upper floors to be used when need arises. The use of ladders as a device to gain access to the rooftops has been reported by Fernea in her experience in the Medina of Marrakech, when she writes: "...I stood up to see who, and my sudden appearance was greeted with exclamations of surprise by a group of women sitting on the opposite rooftop... None of the women wore veil... While I looked back and forth, trying to make it all out [for she did not know about the female use of the rooftops], another head appeared at the top of a ladder that led to the roof" (Fernea E.W., 1975, pp.104-106).

The resulting network seems to be disorderly, erratic and lacking any regulative principle.

ii- BENI ISGUEN

Figure 2.21 shows an aerial view of the terraces in Beni Isguen. The examination of the first floor plans of houses from Beni Isguen presented in figure 2.22, indicates at first sight, no apparent configurational variation from the houses in Ghardaia. But, a careful inspection reveals that the difference seems to lie in the structure of the upper terraces. In Beni Isguen, there seems to be more houses with another arcade at the upper terraces which is much smaller in size than the first floor arcade, forming a kind of a second floor with larger area of terrace. Nine out of twelve examined houses have a second floor arcade; while in Ghardaia, only one out of twelve houses had an arcade at the second floor level. This morphological difference seems to result in much less private roof areas at the second floor, and therefore larger surfaces of upper terraces punctuated by skylights, the only means of light and ventilation for the building below. However, this remains a limited evidence to examine the differences in roof configurations between the two towns and more material, such as a detailed roof plan for Ghardaia, is required to substantiate this claim.

Figure 2.23a shows a roof view of an entire block of houses. The accessibility of the upper terraces with

FIG. 2.21 : BENI ISGUEN, GENERAL VIEW OF TERRACES

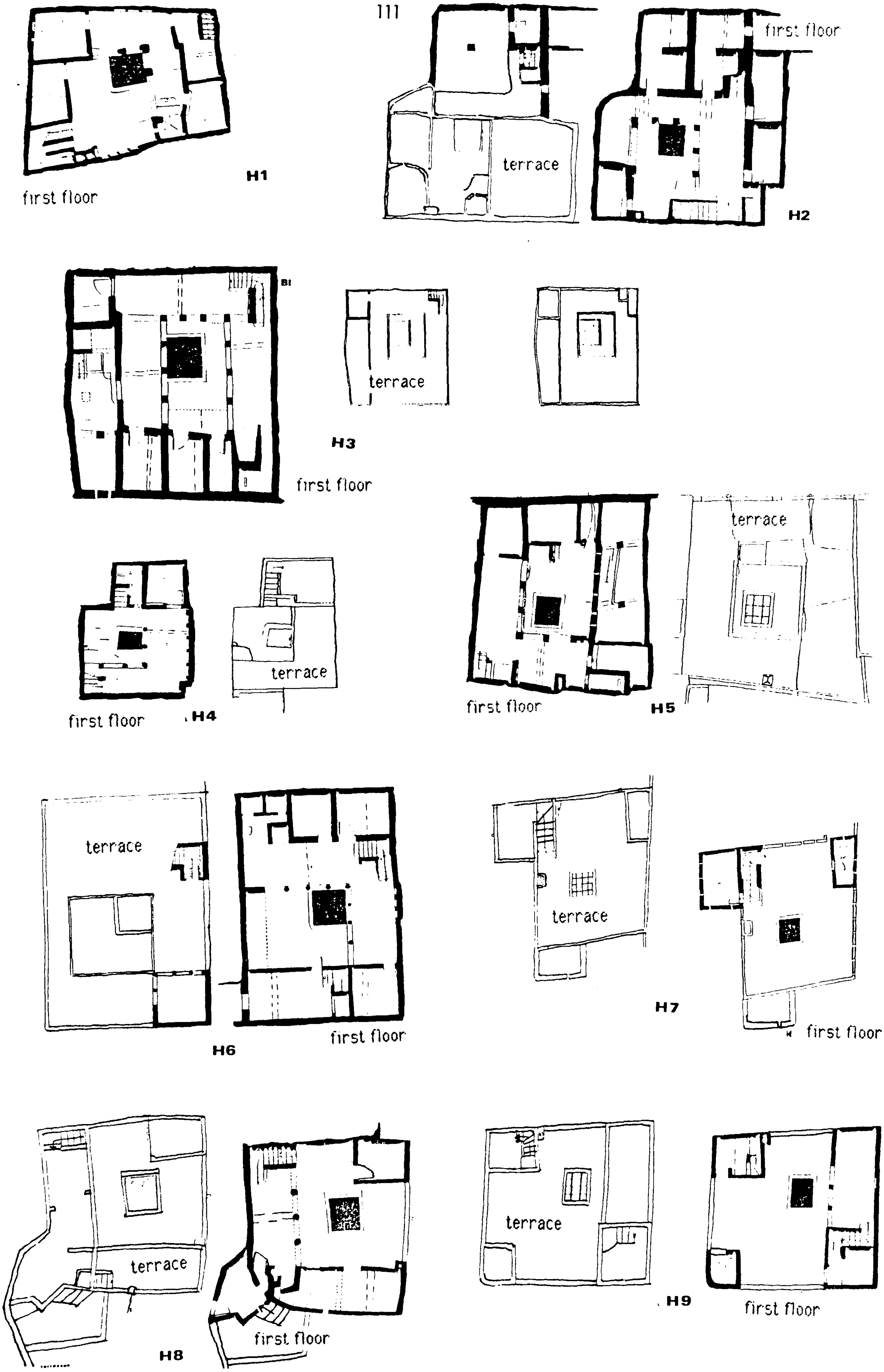


FIG. 2.22 : BENI ISGUEN, ROOF PLANS FOR SEPARATE HOUSES

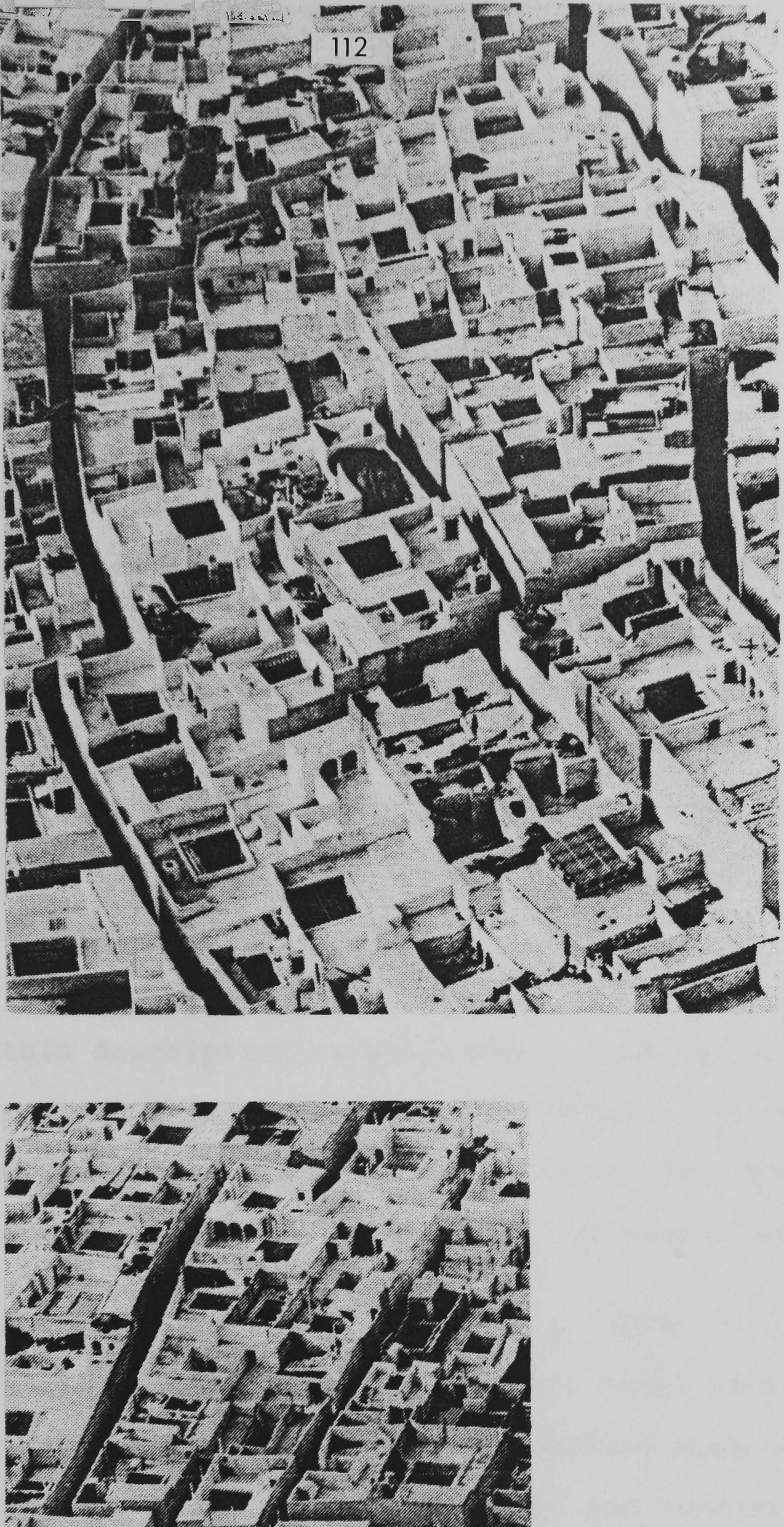


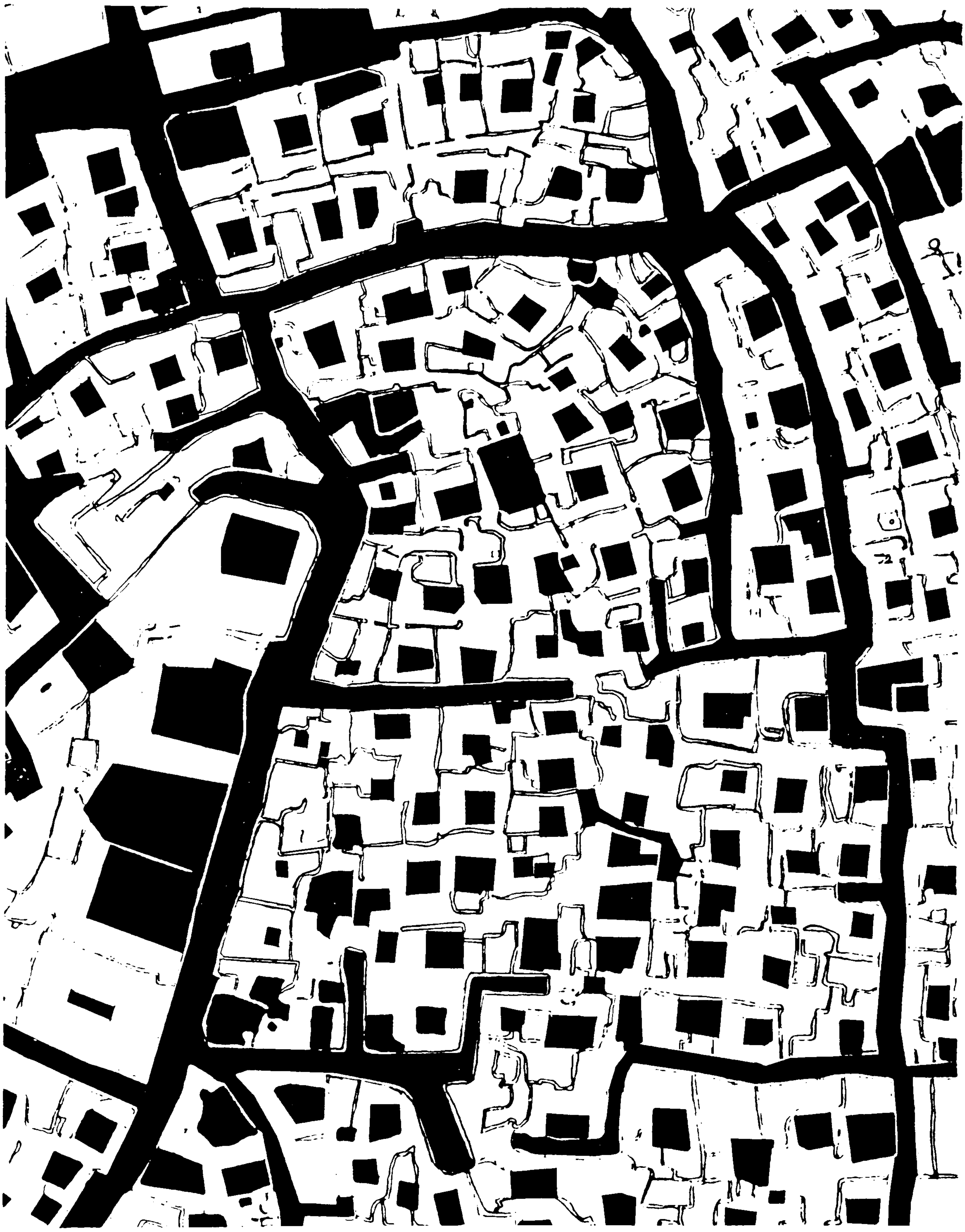
FIG. 2.23a, 2.23b BENI ISGUEN, VIEWS OF TERRACES OF TWO BLOCKS OF HOUSES

respect to each other seems to be restrained only by the voids of the upper courtyards. Occasionally, parts of the roof area are isolated by high partition walls. Access doors to these areas can be also seen from the picture.

The examination of an aerial view of another block of houses in figure 2.23b, shows a different organisation of the roof area. For this block, the partition walls of the individual houses are high, but delineate a smaller roof area than the terrace surface of the houses, leaving therefore a common open area to which access to individual houses is directly gained by means of doorways.

From this description, a preliminary conclusion can be drawn: the system of accessibility between the terraces of the individual houses varies from one block to another, and sometimes even within the same block.

The roof plan presented in figure 2.24 covers two blocks of houses situated in the older part of the town, east of the main mosque (see Ground plan in fig. 2.17). The streets and courtyards are represented in solid black, and the double fine lines represent the sections of the partition walls at the terrace level. The spaces left in white represent the upper terraces of the houses within the blocks. Small differences (up to 0.50 metre) in the level of terraces are ignored and not shown on the roof plan. No clear structure seems



SKYLIGHT

WALLS SEPARATING TERRACES

ROOF AREAS USED BY WOMEN

FIG. 2.24 : BENI ISGUEN, ROOF PLAN

to emerge from the resulting pattern of the terraces and links seem to take place haphazardly. Sometimes, terraces cross over the streets and cul-de-sacs, increasing therefore roof links between houses that are separated at ground level.

Some morphological differences are already noticeable between Ghadames and the Mzab towns, such that the overall urban structure of Ghadames is more fragmentary than the Mzab towns.

CASE STUDY FOUR: EL OUED

GEOGRAPHICAL CONTEXT:

The Souf region is geographically located north of the "grand oriental erg", which is a vast territory mainly constituted by sand dunes (see Location Map in fig. 2.1, p. 27). It is at the south-eastern part of Algeria at about 12 kilometres from the Tunisian border. The wind is the most important physical constraint. The "Bahri", the prevailing wind from the east, is the most violent and destructive factor feared in this region of the Sahara.

The characterisation of the Oued Souf as a Saharan oasis does not do justice to the particular features of the region. The landscape as well as the conditions of life seem to be closely related to the special techniques of cultivation. This particularity lies in the plantation method. The technical problem is naturally in the usage of water resources; here the water table is quite shallow from the surface which is made of very fine and moving sand. The solution adopted is, not to bring up water to the ground level (i.e. by digging wells) and then use it to irrigate the fields, but to lower the ground level by digging a large hole and planting it with palm trees, so that the roots of the trees will be as close to water as possible.

This system has resulted in a technical and agricultural cell necessarily linked to the plantation technique, characteristic of the Souf region: the "ghout" (see Aerial Photo in fig. 2.25).

HISTORICAL AND ECONOMIC BACKGROUND:

The Souf has always been a refuge for several populations coming from different origins ("Kitab El Adouani", translated By Ferauld, C., Constantine, Arnolet, 1868, p. 173). The Souf is highly isolated region. According to Bataillon, this isolation had a consequence on the morphology of the settlements which unlike the other Saharan settlements are not surrounded by outer walls (Bataillon C., 1955, p.20). The whole region is protected against the aggressors by its topography. This particular location made the Souf unknown in the history of the Sahara.

The creation of the palm tree plantations in the Souf and the establishment of about twenty settlements in this isolated region is not the result of haphazard act. Like the Mzabites (*), but for different reasons, the site had been imposed on the inhabitants of the Souf by historical events.

According the "Kitab El Adouan", the population of the Souf is mainly constituted of two groups: the Troud and the Adouan (Ferauld C., Constantine, Arnolet, 1868, p.31). Ferauld has given a percentage of the two groups, which is according to him the 2/3 of the population are Troud, while the remaining third are of Adouan. Most of the settlements of the Souf are constituted either completely or partially of Adouan, except for El Oued where most of the population are Troud (Ibid, p.70). It is very difficult to refer to this genealogical history, since most of the tribal relations between people are often based on a mythical rather than real kinship.

The Troud belong to the tribe "Ouled Zein" which had fled from Syria in the direction of Gabes, south Tunisia, through Egypt and the Tripolitaine. After their expulsion from Gabes, they went to Qairawan, where once more they were not allowed to stay and settle; then to Mohdia in which they spent three years. During this time, the tribe leader was an old wise man called "Trad Ben Dabes", and from which derives the name of Troud (Ibid, p.33). After heavy taxes imposed by the local

* The inhabitants of the Mzab region.

authorities of the town, the Troud decided to leave Tunisia.

They started moving west in search of a new site, crossed the region of Oued Souf, and decided it was too arid for the huge stretches of sand. They then continued west until they reached the region of Oued Rhig. There, the water was very abundant, but they quickly realized that the place was infested by malaria. On their way back to Tunisia, they noticed that despite the arid appearance of the Souf, water was in fact at easy reach (ETAU, 1979, p. 34).

Most of these events took place at the end of the 14th century. However, the "Kitab El Adouani" explains that the Troud are not the very first occupants of the Souf (Ferauld C., Constantine, Arnolet, 1868, p.66).

A refuge land, the Souf was part, according to Brunschvig (Brunschvig, R., 1942 and 1947), of the kharijit block of South Tunisia, and this conversion to the Orthodox sect dated from the 12th century (Ibid, p. 330). The population is Muslim orthodox and one important aspect of the religion is that each group, so small was it and every hamlet, is provided with a mosque, which is sometimes only a praying room built close to a well.

SOURCE MATERIAL:

The region of the Souf is made up of about 20 settlements, the most important one is El Oued. Only one town in the vicinity of El Oued is used in this study as a reference case.

The ground plan of the settlement and several house plans were provided by the ETAU (*). In addition to this material, an aerial view of the settlement has been produced by the "Institut de Cartographie, Alger". No detailed field research has been carried out, but several visits to this settlement and others in the region have been made.

THE BUILT ENVIRONMENT:

A visitor to the region of the Souf is usually surprised by the uniformity of its architecture. All buildings are dome-roofed. El Oued is known as the city of one thousand domes (see Aerial Photo in fig. 2.25). Similarly to the inhabitants of the Mzab, the Soufis have developed two forms of habitat: the winter settlement, the settlement with its relatively dense form of housing, and the summer residences implemented in the gardens for the surveillance and maintenance of the cultivated land (Bataillon C., 1955, p. 15).

Most of the Souf settlements, by contrast to the other Saharan settlements, are not fortified and protected by a surrounding outer wall. The other most characteris-

* ETAU stands for "Entreprise des Travaux D'Architecture et d'Urbanisme".

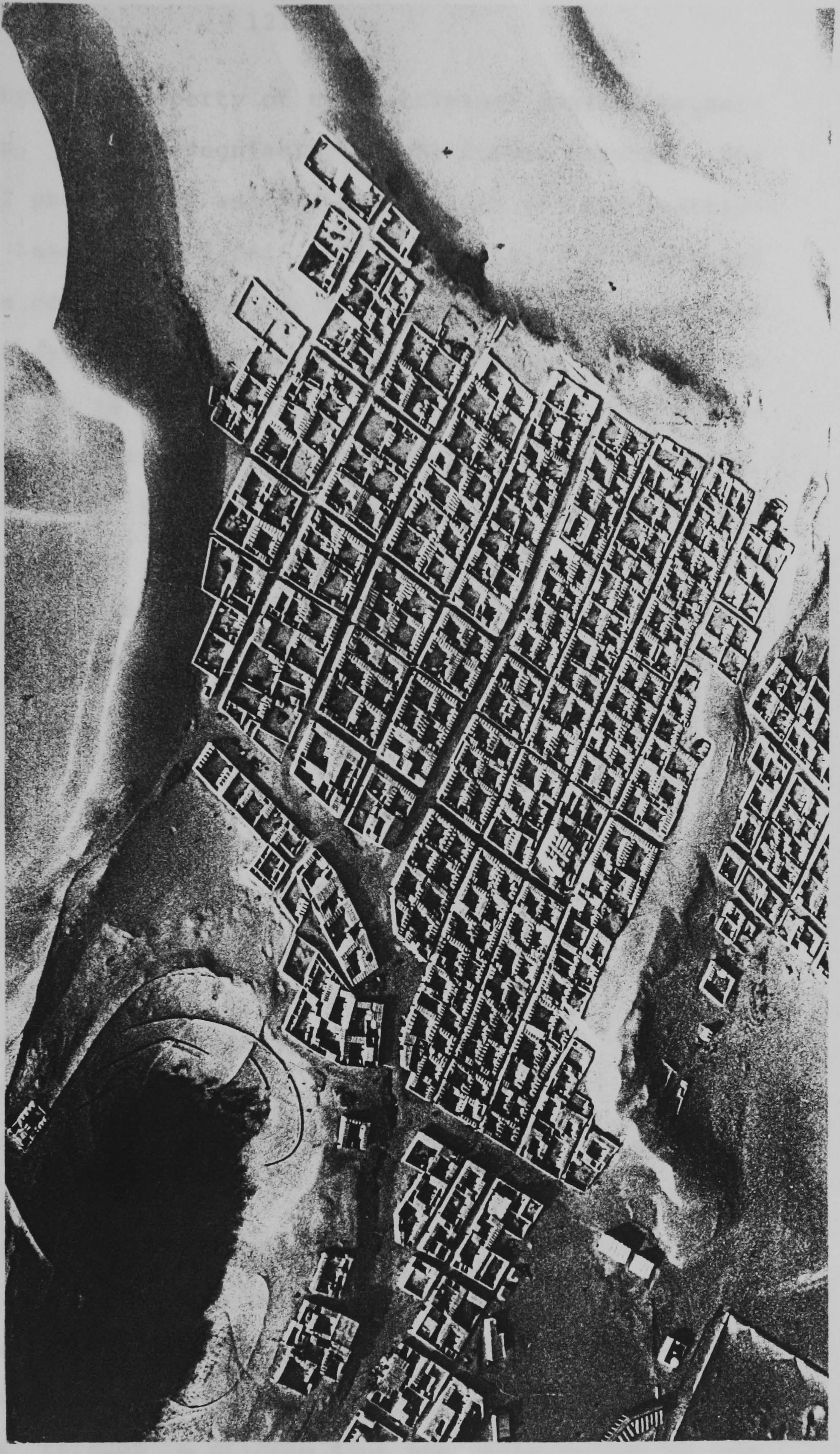


FIG. 2.25 : EL OUED, AERIAL PHOTOGRAPHY

tic physical property of the settlement spatial organisation, is the regularity of the street network. The aerial photography and the ground plan of the settlement (see fig. 2.26) show an aggregate of courtyard houses connected together by an orthogonal grid-like street system. The streets are completely covered with sand which is prevented from settling on the domed-rooves of the buildings. In proximity of the "ghout", the buildings tend to follow the curved shape that originated from the circular agricultural cell. The mosque is located at the southern part of the settlement. It is not a free-standing building and its roof is constituted by the same modular dome element.

THE DESCRIPTION OF HOUSES IN EL OUED:

The internal structure of the houses denotes a specific pattern of life which seems to have hardly change since the Soufis first settled (Bataillon C., 1955, p.50). The architectural characteristics, i.e. the dimensions of the rooms, seem to be closely related to the construction techniques. The dome constitutes the building module (see House Plans in fig. 2.27). The houses are invariably one-storey building and built around large and sandy courtyards that do not connect to each other. The access to the house is always protected against visual corridors from the outside. It is always through a chicane that one gains access to the interiors. This chicane varies in size, and is in most of the cases, directly connected to a reception room

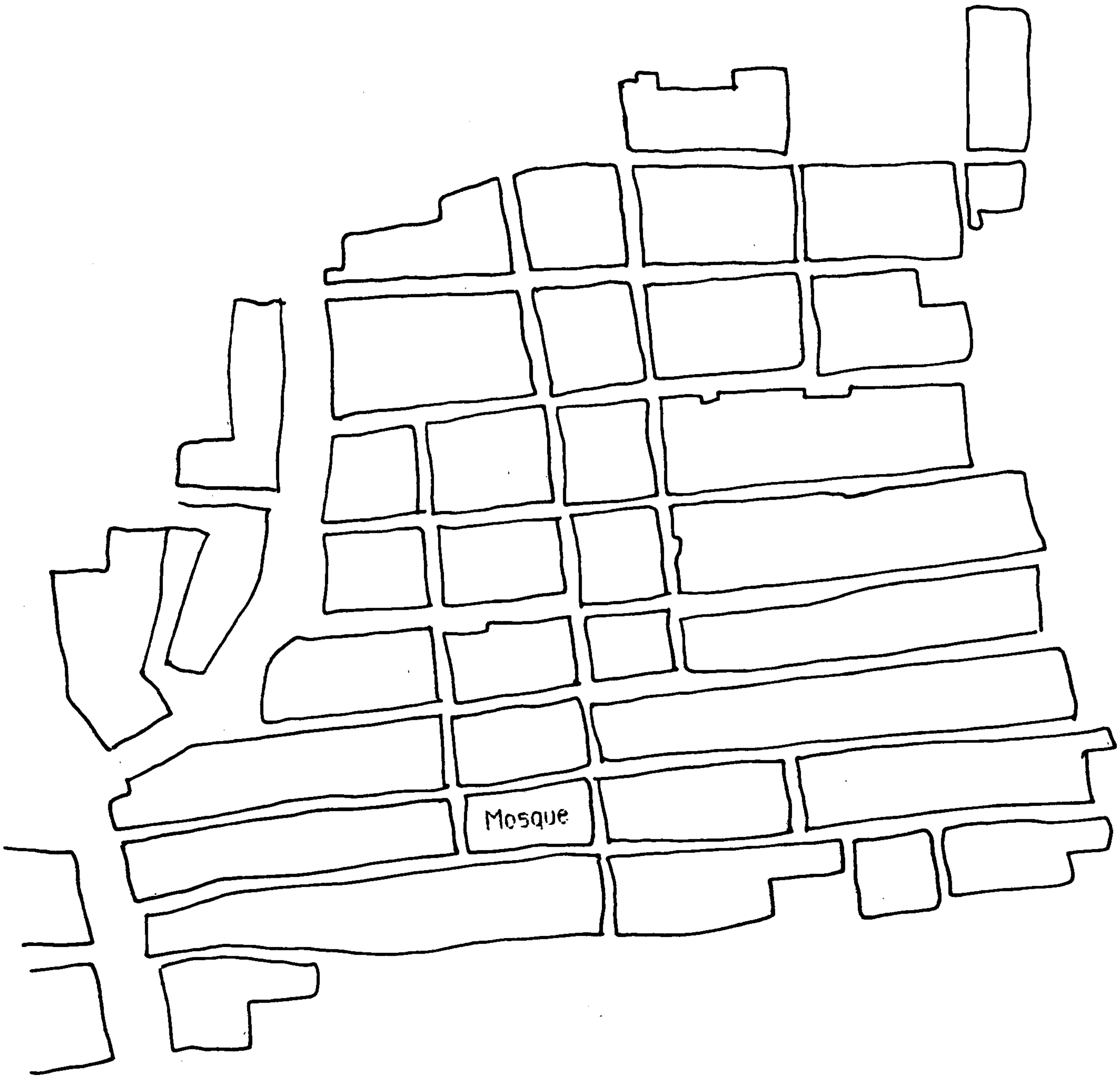


FIG. 2.26 : EL OUED, GROUND PLAN

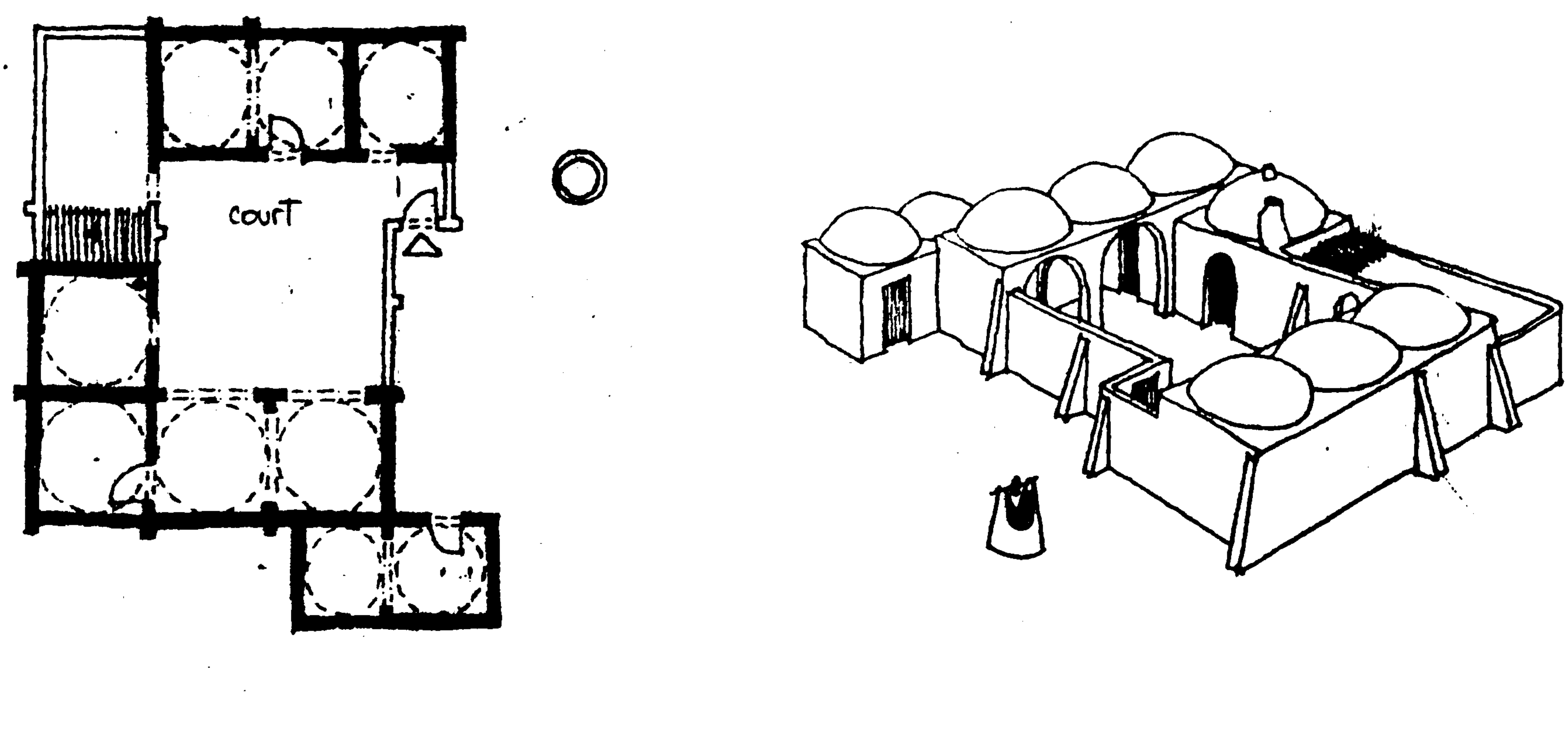


FIG. 2.27 : EL OUED, HOUSE PLANS

for the male guests. All rooms are distributed around the courtyard. An arcade (porch) runs on one side of the courtyard in front of the individual rooms. In some cases, the arcade is built all around the courtyard, forming therefore an inner ring of covered but open spaces. On one side of the courtyard, there is a series of small rooms used as utility rooms, such as toilet, "water room", and stable for the domestic animals.

El Oued, in contrast to the other towns, has displayed a visible regularity in the street pattern as well as a distinct house form. The presentation of the towns has clearly shown the presence of different cases of the so-called "Arab town".

SUMMARY TO CHAPTER ONE:

The first chapter of Part One of this study has been mainly concerned with the presentation of historical, social and descriptive material of the towns in question. The description of the built environment, especially the section concerning the upper terraces, is based on first hand data resulting from the author's field surveys, but also elaborating this whenever possible with accounts drawn from relevant published material. This chapter has clearly shown the existence of morphological differences and similarities between the individual cases.

CHAPTER TWO: THE SOCIAL USE OF SPACE IN THE MZAB TOWNS AND GHADAMES

INTRODUCTION

In the section that follows, some aspects of the social and cultural systems in the towns under study will be outlined, in particular, the system of relationships of men and women, and its effects on the way space is used by the two social groups. The section aims then to present a description of the social use of space in the streets and at the terraces, on the basis of the author's own data which is elaborated whenever possible with accounts drawn from literature. This description concerns chiefly Ghadames and the Mzab towns, Ghardaia and Beni Isguen. El Oued is used mainly as a reference case in the present study and no detailed ethnographic data on space use has been collected.

Since this thesis, among many questions, deals with the structuring of the urban space and the way it is used by the different groups and particularly by women, the examination of the society from a female perspective seems to be a particularly appropriate topic of study. Such a description should provide the proper setting and a suitable background for analysing the systems of relations within and between the sexes.

Studies on social life in these towns have stressed one aspect of life, that is the separation of men and women (i.e., Lamphere, 1974, p. 97; Springer-Verlag, 1967, p. 120; Parveen S.A., 1976, pp. 127-130), and the restrictions on women in terms of mobility, that is the limitations that are imposed upon them in a physical sense.

The separation of social life into men's and women's domains has been seen as a primary characteristic of life in the towns under study and Arab towns in general (i.e., Addoun A.D., 1977, p. 36; Burckhart T., 1980, p. 166). This is mainly supported by observations made on public life, such that women walk veiled in the streets alone or with other women; boys and girls attend separate schools; markets and cafes only frequented by men, and the main worship areas of mosques reserved only for men and for women smaller areas are separately established (i.e., Gordon D.C., 1968, p. 17).

Indeed, the division of social life along sexual lines is most apparent within the public, the more "visible" domain, but also in more private settings. For example, in everyday socializing, women tend to gather with women friends and neighbours, while men typically congregate with their male friends and fellow-workers. Women tend to meet in their houses and on the rooves, while men more often gather separately in stores, mosques and in the market, outside the houses. On ceremonial occasions, the two groups are also strictly kept apart. Women congregate separately from the men who have been invited to the same celebration.

The separation of the sexes is maintained most consistently and is explained most explicitly within the realm of religion (i.e. Addoun A.D., 1977, pp. 36-38; Gordon D.C., 1968, p. 12). Men pray in the mosque, make up the membership, and are the religious leaders. The women are generally excluded from these roles and from the more visible devotions. Such separation is believed to be sanctioned by God in order to limit sexual temptation and involvement. The separation of the social spheres along sexual lines is based upon the principle of modesty and honour. A woman, it is felt, must be protected from those men who might seduce her. This is necessary in order to preserve her own modesty and her family's honour (Ibid, pp. 33-34).

However, what seems to be the case is that men and women in these societies, do not really lead mutually exclusive lives. On the contrary, there are complex rules which ensure the interaction of men and women, and govern the way in which it occurs. For instance, spouses traditionally take meals together, and in most families, they provide advice to one another. They frequently exchange gossip and town news. Fathers and brothers show active concern and interest in their daughters' and sisters' welfare, and on family occasions, men congregate in the presence of their kinswomen.

While it is true that husbands do interact with their wives in the way described above, it is also accepted in the Mzab and Ghadames societies that men should leave their wives each day, for the home is considered per excellence as an area of women (Donnadieu and Didillon, 1977, p. 71; Addoun A. D., 1977, p. 47).

In the economic sphere, and for all towns considered, men invariably engage in trading, farming and crafts ; while women work at such jobs as curing, midwifery, wool spinning and rug weaving, sewing, cooking (for ceremonial gatherings) and laundering. In most (if not all) cases, women constitute women's main clients, and in almost all cases male-female interactions within the economic realm are almost non-existent. In the Mzab towns, some clergymen are given the task to sell and buy products for women, since these cannot contribute in the auctions taking place at the market place (Addoun A. D., 1977, p.58).

In political sphere, men fill most offices. In the Mzab towns, one female group is attached to the political or judiciary system: the "Timesridines or Azzabat", a sort of a female council. Appointed by the town council, the "Timesridines" collect information from women. They protect them, check pregnancy, provide the last blessings (Ibid, p.54). Because male officials are prohibited from entering into such exchanges with women, the "Timesridines" emerge then as an essential liaison between the sexes. None of these female associations has been reported to exist in either Ghadames or El Oued.

Clearly, the importance of the principle of separation seems to be significant only if one looks at the "more visible" aspects of social life as outlined above. While it is true that the sexes are segregated from each other, it is also true that the mechanisms by which this separation is realized vary, both socially and spatially from one case to another. The puzzle is that there exist different practices of space use by men and women in the different towns. The consideration of these facts suggests a much more complex situation, in which there seems to be rules about how men relate to each other, rules about how women relate to each other, and rules about how the two "domains" created by the rules interact. The effects of these rules on space use by men and women seem to vary from one town to another. Therefore, the idèa of separation as the primary principle of order seems to be limiting and an inadequate description of social life in these towns, including the social use of space. The following section will concentrate mainly on the social use of the streets, the houses and the terraces in Ghadames, and the Mzab towns considered together.

THE DESCRIPTION OF MEN'S AND WOMEN'S WORLDS:

Most of the following information is based on personal experiences and observation made on site during the several visits to the towns at different times of the day; as well as the numerous interviews and discussions with both men and women (*).

In the Mzab, the author was forbidden to photograph women. All of the pictures, both for the Mzab and Ghadames, were taken with the permission of the inhabitants. In many cases (especially in the Mzab) this permission was not granted.

Kept separate, although to varying degrees, the women in these towns have tended to develop their own world within limited boundaries, a world which is relatively insulated from men. Men, for their part, have developed a man's world into which women only rarely enter. These worlds exist as forced outgrowths of the sex segregation, while also serving as strategically defined spheres, which present a refuge for both sexes from the tensions of male-female relations.

The complex separation and joining of the two "worlds" reveals itself in the physical and temporal division of life space. The household, for example, is a joint living unit for men and women, but during certain hours of the day, it becomes more of a female domain.

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* I was invited to several parties taking place during my visit to the towns. In Beni Isguen, for instance, I have attended a religious ceremony celebrated to commemorate the death of an old woman. In Ghadames; I was first invited to a birth celebration and the second time to the preparation of a wedding ceremony. Apart from that, every day I was invited to different houses for lunch, coffee...

PATTERN OF SPACE USES OF THE HOUSES:

The pattern of use and labelling of space does not seem to differ in Ghadames, Ghardaia and Beni Isguen. It is complex, and changes with the absence of men. During the day, however, when only women and small children are present, the domestic space is used much more in common. Women of the household follow the same work timetable and share the courtyard, kitchen and the roof terrace, and may also share provisions and utensils. Relations between women members are normally close and informal, though when household fission occurs, it is usually due to a breakdown in the women's relationships (i.e., Addoun A.D., 1977, p. 56). The roof serves as an extension of the workplace, for laundry, for drying foods of various kinds, for processing raw wool.

When the men of the household are present, the use of the domestic space alters. One or two rooms are reserved for receiving male visitors and the women avoid them; these rooms are segregated from those used by the women. In Ghadames, this room when it exists, is usually at ground floor, in Ghardaia and Beni Isguen, it is at the first floor with a separate staircase linking it directly to the outside, and in El Oued, the separate room gives directly onto the street. (see House Plans in figures 2.9, 2.20, 2.27).

A woman's life is largely centred in the area around her home as will be described in the following. Men play little part in the running of the home, and spend much of their time elsewhere. In the Mzab, most of the young men emigrate to the north for work, and have most of their social contacts away from the house (i.e. Etherton D., 1971, p. 187). Despite these separate patterns of activity, the family is prized as the unit on which society rests (i.e. Addoun A.D., 1977, p. 51).

MEN'S AND WOMEN'S USE OF THE STREETS IN GHADAMES:

Some streets in the separate quarters of Ghadames except for Bellil, have been shown to be furnished with masonry benches intended for men's uses (see fig. 2.4, 2.5 and 2.6). When not at work, men of the quarter congregate in these streets where they sit, chat and drink tea prepared in situ.. During the hot hours of the day, these streets are preferred for their freshness for sleeping (siesta). Yushea tells a story about a governor during the Turkish administration who used to block two ends of a street and put a bed for sleeping (Yushea Q.B., 1973, p. 94). On ceremonial occasions (i.e., wedding), these streets are sometimes used as a reception area for male guests. The street's floor is then cleaned up and covered with woollen rugs (Ibid, p. 195).

Women use the streets at ground level mainly to go to the fountain to fetch water, to go to the mosque, laundry house or for visits beyond the quarter. Visits to the local fountain are usually programmed in time (late afternoon prayer) during which men avoid wandering in the streets (Ibid, p. 84).

WOMEN'S USE OF THE TERRACES IN GHADAMES:

In Ghadames, various uses are linked with the roof terraces, ranging from everyday activities such as cooking, food drying, wool processing; to more formal ceremonies, such as wedding and birthday parties. Selling and buying of goods such as sweets, perfumes, hair dye, material for dresses, also takes place at the rooftops. De Motylinski has referred to the existence of a kind of a market for women at the terraces (De Motylinski, pp. 55-56; Yushea Q.B., 1973, p. 84). Tea and coffee parties are also held at the rooftops, and most of the female visits to relatives and female friends, even at night, are accomplished via the roof terraces.

One case has been included in this chapter in an attempt to show the extent to which the roof terraces are used by the women, and their role in the female society.

Pattern of uses of the terraces in the performance of wedding ceremonies

The information used in the following description comes from two sources. First, is the personal attendance of the author of the wedding preparations. The second source is Yushea's book in which he gives a very detailed description of all ceremonies that take place during the preparations for a wedding (Yushea Q.B., 1973, pp. 204-242).

In order to fix a day for the wedding, the female members of the bridegroom's family discuss with their counterparts in the bride's family and both parties then settle on a convenient Friday to start the preparations (Yushea B.Q., 1973, p. 205). When a date has been agreed upon, early in the morning of that day, the groom's female "servant" (designated lady of honour) goes up onto the upper roof terrace of the groom's house and starts ululating. All women friends and relatives of both families when hearing the "ululations" come to the groom's house via the roof terraces, singing special songs. This represents the formal announcement of the beginning of the wedding festivities which will last for two weeks of preparations and an endless stream of events and ceremonies to and from the bride's and groom's houses.

The first event which takes place in both the bride's and the groom's houses, is the cleaning up and distribution of grain, wheat among female friends for grinding. Any woman who wishes to express her feeling of friendship towards the groom and his family shows this by the amount of grain she takes for pounding. Other women receive the flour brought back from the women who have ground it, sift it and put it into bags. This flour will constitute the provisions for the wedding meals. On the same evening, a ceremony which involves only the "unmarried girls" starts. The young girls come by way of the roof terraces to the upper courtyard of the bride's house to amuse themselves, sing and dance together on the rooves. This is a sign that the festivities have begun, and the girls will do this every night until the following Friday. This is brought to an end by holding a party at the terraces of the bride's house, called "the tea of the girls".

The next ceremony which also takes place at the roof terraces, is the "seed roasting" (i.e., flax seed, wheat, melon seed...). These are put in cloth bags and kept until the day called "the mixing" to be distributed among the guests. Meanwhile, another activity is taking place at the courtyard roof terrace; this is called "the dying of the woollen threads", which will later be plaited into the bride's hair. All women relatives and friends are informed and can have some of their woollen headwears dyed along with those of the bride.

In the following day, the couple's new house is entirely whitewhashed from top to bottom, by women relatives. When the whitewashing is dry, the decoration of the house is carried out by specialized women. The evening of the "whitewashing day" is called the night of congratulations (Ibarak). A group of women from the groom's house get to the roof terraces and start calling and shouting "listen all you women, tonight is the congratulations of "so and so" son of "so and so". They shout this as they make their way along the pathways of the roofs towards the bride's house. On hearing this, all the women friends and relatives come to the groom's house via the roofs (Yushea Q.B., 1973, p. 206).

On the day of the writing of the wedding's contract, the women come to the groom's house by way of the roof terraces, one by one or sometimes two at a time, walking very slowly and escorted by their "servants" who ululate all the way to the house. For the writing of the contract, men go to the mosque to witness the marriage; two female "servants", one of the groom and one of the bride who were standing outside the mosque, as soon as they hear the exchange of congratulations between the two parties, start ululating and continue to do so all the way back to the house, where the women are waiting to be informed that the writing has taken place. At the house, the two female servants continue ululating and go up onto the roof terraces; there they will be followed by other women, singing, playing the drums and all dancing. Then they form a procession, walking very slowly in a single file to carry the news of the writing to the bride's house (Ibid, p. 218).

Endless ceremonies take place all accompanied by music and dances; in one the bride is seated at the courtyard roof terrace which is all covered with carpets, and the women come and go via the roofs to look at her and congratulate her. Several meals are distributed and on a particular day, food is given to all relatives and neighbours who do not cook meals on this day. The distribution of food is done by women relatives of the groom by way of the terraces (Ibid, p. 238).

On the wedding day, the bride is taken up to the courtyard roof terrace for all her hair to be made into small thin plaits by specialist female hairdressers. There, the women are already waiting seated to see the bride, under the sound of music, songs and ululations. After this, the bride is taken down to the house to be dressed up into her nuptial dress (Ibid, p. 236). She is taken once again up to the roof terrace, where the women are waiting to see her before she is taken to her new house.

Thirty days later after the marriage, the bride visits her parents' house. Her sister or one of her female relatives comes to accompany her to the house by way of the roof terraces. The bride takes with her all her jewellery and a new dress. After the late afternoon prayer, she puts on the new dress and jewellery, she is then seated in the courtyard roof terrace where the women friends and neighbours come via the roofs , to see her and take tea with her. After the evening prayer, women from the groom's side come to take her back home. On their way back, by way of the roof terraces, she pretends she does not know the way to her new house and must be constantly guided by the women (Ibid, p. 239).

FEMALE SOCIETY AT THE "ZENKA" IN THE MZAB TOWNS:

A clear demarcation of the public world and the predominantly female world within the dwelling is then the arrangement which prevails when strangers or men are present. But just as the pattern of use of the house itself changes in the absence of men as seen in the preceding section, so does the distinction of the house and the street, which becomes less rigid. The interface of the house and the street allows at all times a "surveillance" by women (Donnadieu and Didillon, 1977, p. 71). This discrete contact between the two worlds becomes more visible when men are away at work. Similar observations have been reported in other towns. For instance, Fernea, in her accounts on Marrakech comments:

> "I began to notice that the women did talk together informally, not across the rooftops only but also from the open doorways of their houses, always keeping one foot on the sill, so that they could quickly step inside if a man appeared in the street." (Fernea E. W., 1975, p. 157).

The "local" street provides a highly complex interactional world for women in the Mzab. In local language, the local street is called "zenka". The "zenka society" exists only for women and children. Its boundaries are indistinct and may vary over time. Women undertake a variety of activities within the "zenka": social, religious and economic. The fact that there is a local name for this type of social entity is in itself of a great interest.

During the hours that men are at work, women move about rather informally; they go from house to house and from woman friend to another with comparative ease. In some streets, women even gather in passageways to work or to chat (Ibid, p. 156).

The "zenka society" exists in gossip, on regular visits to the public bath (locally termed Hammam), to do laundry, and in a variety of small exchanges when men are away from the house. Friendship is expressed through exchange of gifts and visits, the giving of help on ceremonial occasions, the open possibility of lending and borrowing, and frequent opportunities for chatting and gossip. Proximity facilitates these activities, while distance, such as is occasioned by a move out of the area, severs even long standing female friendships (i.e., Fernea E.W., 1975, p. 135). With regard to privileges and obligations, the role of the neighbour seems to be much more important for women than for men. The "zenka society" exists as well in more formal visits, on social occasions to each other's houses for women's parties. Distinctions of economic status are relatively insignificant in the "zenka" society (Fernea E. W., 1975, pp. 108-109). Consciousness of social standing is strong, but social interaction does not seem to be governed by it.

The "zenka" is therefore a multifunctional female unit. It has social functions which women zealously carry through: the women of a "zenka" unite on certain occasions; for example to take a bride to the public bath on the day of her wedding (*), or to prepare wool (combing, spinning...) for rug weaving. This grouping for "giving a hand" is called "tuisa" (Addoun A.D., 1977, p. 36). They are invited to any and all family celebrations within the locale (Yushea B. Q., 1973, p. 189). Men of a street do not seem to develop comparable social networks. They occasionally meet with neighbours, but they typically do not involve themselves in festivities and the social life of the "zenka". For example, male neighbours do not help with the preparations for the festivities, and do not attend the ensuing celebrations, nor do they invite a substantial number of male neighbours to family ceremonies (Ibid, pp. 220-223). Instead, there is a relative lack of social involvement which tends to reflect some friendliness but also a reserve.

MALE SOCIETY BEYOND THE "ZENKA":

Whereas women most often interact in the household, the "zenka" or the terrace, men generally range more widely as they establish and maintain social ties. They keep relations with near and far kinsmen and friends, and they do this in diverse localities (Donnadieu and

* This event is called "Hamman El-Khalẃa".

Didillon, 1977, p. 34). For all men, however, the workplace (in the valley of the Mzab or as emigrants), the garden, the market place appropriately insulated from women, provide primary setting for socializing, where they sit in small groups, chat and drink tea. Occasionally, men invite their male guests to their houses in order to entertain them.

Male society is not dependent on spatial proximity. Outside his house, a man can choose on an individual basis, those with whom he wants to interact within his Mzabite community. Men move freely, both to work or for social contacts. Of far more significance for social interactions than the mosque or the market is the "zaouia", a lodge of religious scholars. Religious lodges are numerous and usually consist of one room with a separate entrance from the street, annexed to mosques; they serve as the meeting place for men (i.e., Yushea Q.B., 1973, pp. 268-270).

In these terms, male contacts seem then to be relatively less constrained spatially. The individual man is mobile across the whole town in pursuit of his contacts. This mobility extends beyond the town (i.e. the male emigration to the north of the country). The male social structure unlike that of the women in the locale, is not destroyed by moving residence even away from the town, as it is the case for the male emigrants, since their grouping and social ties do not seem to be dependent on space.

WOMEN'S USE OF SPACE BEYOND THE "ZENKA":

Women, when they leave the "locale", travel only to certain designated places for designated purposes (to go to the cemetery or to the gardens,, visit a relative living in other parts of the town...). The presence of a woman in the public places confers no rights of use. Veiled and usually accompanied by another woman, she travels across the public space without using it and is effectively invisible. Even familiar individuals are ignored. Women's destinations are often female preserves, where interaction with other women is possible. A different range of contacts between women from the local "zenka" exists (i.e., Visits to female kin living outside the "zenka").

From this description, a clear model of male-female space use starts to emerge. Some local streets in the Mzab towns form a stage for interactions between women. This female community depends upon spatial proximity, and while the individual woman's membership is transitory, the community itself persists. The "zenka" as a social entity, is therefore a space and time-based unit. The essence of these social activities is that they are permitted not claimed and recognized as a right, and take place only during the absence of the male residents from the "zenka".

The configuration of the local streets seems to contribute in promoting this kind of interactions among women. By and large, the streets where the "zenka" units have been observed, appear to be highly isolated in terms of the whole town, a property which provides a congenial environment for women given the separation of the sexes. Strangers do not enter into these areas, or pass through them to more distant areas. Non-residents have little reason to frequent these streets, for few stores exist inside these areas. Because the "local street" does not draw attention of outsiders, women's behaviour becomes markedly freed within it (i.e., Fernea, 1975, pp. 156-157).

Clearly, the "zenka" unit occurs only in some towns (Ghardaia and Beni Isguen) and is to be found only in some streets. A question follows from this is that the physical form of the street system in these towns may be the key factor in contributing to the proliferation of contacts and social activities among women at the "zenka", in the sense that the spatial structure of the urban space might contribute in keeping male strangers and outsiders away from these areas. Time is also a crucial element as it all happens when men residents are absent.

WOMEN'S USE OF THE TERRACES IN GHARDAIA AND BENI ISGUEN:

In Beni Isguen and Ghardaia, the terrace plays a important role in the functioning of the house and in everyday life of its occupants. As in Ghadames, several domestic activities take place at the terraces. It is the place for cleaning grains, dates, for drying foods and meat for storage, dying wool for rug weaving which is a major preoccupation of the Mzabite women. It is the playground for the young children, and tea and coffee place for the female neighbours. The existence of a small cooking area facilitates the usage of the roof terraces for organising tea and coffee parties.

On ceremonial occasions, food for the party is prepared and cooked at the roof terraces, and neighbours' roof areas are usually used for extra-space. but the party itself is held downstairs at the courtyard which is now entirely covered up with carpets and woollen rugs. The men's party is usually held separately, at a neighbour's house. During these occasions, the rooves become then more of a service area and all functions which normally take place at the courtyard at the ground floor are now performed at the roof terrace; that is cooking, washing up, food storage.

All close female relatives and friends are at this floor helping with the preparation and distribution of food and drinks. If something is missing (i.e., shortage of utensils, rugs or a particular ingredient for cooking...), a woman is sent via the roof, to the neighbour's house to borrow it.

Only one formal event which takes place at the roof terraces has been reported. This is the ceremony which marks the end of a mourning period. Fourty days after the death of a husband or a close relative, the grieving woman (or women) goes up to the upper roof terraces and washes, brushes her hair and puts on a new dress. Women neighbours when seeing her, come via the terraces and gather around her and wish her well. The ceremony is ended by a tea party, with tea and sweets being prepared and brought in by the neighbours (Addoun A.D., 1977, p. 56).

The description of uses of the terraces shows clear differences between the Mzab towns and Ghadames. In this latter, the use and activities in relation to the terraces are much more elaborate. For example, the way in which the wedding ceremonies are conducted seems to depend very much on the extent to which the system offers more distant connections, so that a wider network of interactions could take place involving the entire female population of the quarter. By contrast, the use of the terraces in the Mzab towns seems to be more incidental. The lack of connections at a wider scale in Beni Isguen, seems to introduce extra restriction and control upon women.

SUMMARY TO CHAPTER TWO:

The second chapter dealt with the "ethnographic" accounts on the towns. It has presented a description of the social use of space in the streets and the terraces of the towns in question, and has shown the existence of different patterns of use of the urban space in relation to the different social categories and more specifically with respect to male-female members of the society.

CHAPTER THREE: OVERALL REVIEW OF THE SOCIO-DESCRIPTIVE MATERIAL

This chapter opens up a discussion about the relation between spatial structures and their social dimensions by examining the main issues and claims put forward by past studies, in the light of the socio-descriptive material presented in the preceding chapters. By this, the present section aims to show the theoretical limitations of the concepts used to describe these urban systems, and demonstrate therefore that important questions remain open.

A discussion of issues stressing privacy, uniformity and religion, is first presented by referring to the literature specific to the towns under study, but also drawing on other more general material when is necessary. Then, the section confronts the main claims of these studies against the available evidence, by presenting an overall review of the socio-descriptive material. This chapter ends up by raising the question of what it is about these towns, seen spatially and socially, that might be better explained through a much more elaborate study of the spatial structures.

Towns in the Arab world attracted attention and became a particular focus for speculation for the apparent correlation between their spatial patterns and the system of social relations. As due to the strong separation of men and women, the relationship between the concept of "privacy" and the spatial organisation became the main claim in this vast field of studies.

The idea of an urban space distinctly divided into two domains, the public wholly male as opposed to private which is a predominantly female world, is derived mainly from a casual examination of the town plans and the distribution of uses within them. For instance, the position of the market square in the town fabric, has been often acknowledged as an evidence of this division by many writers to support their argument concerning the organisation of space on the basis of the concept of "public v private" (i.e, Donnadieu and Didillon, 1977, p. 63; Raymond A., 1985, p. 172; Burckhart T., 1980, p. 166). Delaval for instance, explains that the Islamic concern for privacy and the clear separation of public from private life by a hierarchical sequence of progressively more private spaces, was the dominant force in shaping the buildings and interconnecting spaces in the Mzab (Delaval B., 1974, pp. 252-255). The body of literature using the concept of "privacy" is paramount; but only a few references have been drawn upon in an attempt to show the widespread of this notion, whether the spatial description concerns the domestic space or the street network.

The main reason for this focus seems to be the presence of the distinctive forms of space configuration (i.e., the dead-end alleyways, chicane entranceways to houses), interpreted as physical boundaries, separating domains of different social activities. From this, it follows that the importance of privacy as an explanation to spatial patterns is seen in terms of the control over the access to an area (i.e., Delaval B., 1974, pp. 252-258). In this sense, privacy may be seen as the establishment of physical barriers against the outside world. Therefore, the idea of spatially discrete domains appears to be regarded as a fundamental spatial dimension to spontaneous control of interaction between social groups in general, and between men and women in particular. The significance of this point is that if privacy is the ability to control interaction between social groups, then privacy mechanisms appear to be socially, not individually sanctioned. In this case, if the notion of control is at the social level, then space is not required to maintain such order, since it already exists well above space organisation.

In this context, the privacy concept may obscure the possibility to elucidate the real nature of the relationship between social and spatial order which is believed to exist in these towns. Moreover, what is recognised as the relating factor between the spatial structures and the patterns of social relations might not be an external projection of the normative religious beliefs. Even if one accepts "public v private" as a general aspect of social and spatial structures, the concern is not with the universal causality of the logic of these phenomena but with their relevance in explaining differences between spatial systems.

Therefore, the danger inherent in the privacy approach is that only characteristic features (social, i.e. the segregation of the sexes, or spatial, i.e. the court-yard house or the cul-de-sac street configuration) that can be conveniently classified within the imposed abstract model are considered relevant. For example and within this framework, the spatial forms in the Mzab towns, Ghadames and El Oued are described as strongly exhibiting similar characteristics at all levels of organisations, mainly originating from the basic religious need for privacy, and this can miss out the equally distinctive global configurations of these towns. There is no doubt that religion is a common denominator to these towns, but there is no doubt also that the housing type in El Oued presents substantial variations from the housing type in the Mzab towns or in Ghadames. For example, the large open court, the absence of the terrace system and its presence in Ghadames is certainly a fundamental morphological difference in the organisation of these towns. The consideration of these facts makes it impossible to follow the common practice when faced with an individual case of assuming the spatial form to be only determined by some external factors such as religion. The real problem with this conceptual model is that it is based upon similarities, and the most pertinent question would be: how could one explain differences in the configurations of these towns when the basic concepts used in their description are assumed to be similar and invariant? This fact by itself raises doubts as to the interpretations placed upon the spatial organisation of the towns in question.

Clearly, the description of the towns has shown some similarities in terms of climate, religion and economy. From the geographical point of view, all four towns are located in the Sahara, that is within the same general climatic and environmental conditions. All of the towns are inhabited by a Muslim population which, according to some historical sources, belong to the same broad religious sect, the "Ibadhite" school.? From no !! the economic point of view, trade and agriculture are the main economic activities for all towns. Although in varying degrees, all of these factors, seem then to be invariant for the towns under study.

However, from a morphological point of view, these towns present fundamental differences at various levels of their spatial organisation. These can be summarized as follows:

i- <u>At the level of the town fabric</u>:

- Unlike the more compact morphology of Ghardaia and Beni Isguen, Ghadames is made up of distinct individual quarters with, except for one quarter, all streets and alleyways entirely covered up by buildings spanning over them. Some of these streets are furnished with masonry benches. In Ghardaia and Beni Isguen, streets are only occasionally built over; while in El Oued, the streets are not at all covered up. These distinctive characteristics may be the result of technological differences between the towns.

- The town fabric of the separate quarters of Ghadames presents an irregular and dense morphology, composed chiefly by three storey buildings, except for Bellil quarter where the buildings are only one storey high. The streets and alleys of Ghardaia and Beni Isguen divide the urban fabric into distinct blocks which vary considerably in shape and in size. These blocks and the surrounding streets tend to become more regular in the more recent parts of the towns. Close packing of buildings is the norm and buildings are two to three storeys high. For El Oued, the overall urban fabric presents by contrast to the other towns, much more regularity in the street structure with a clear lack of deformation of the grid as observed in the other cases. The buildings are one-storey high with non-accessible roof terraces.

ii- <u>At the house level</u>:

Important differences exist between the internal organisation of the houses in Ghadames (excluding Bellil quarter) and the Mzab towns, and this seems to have some bearing on the terrace configuration and use. In Ghadames, the location of the kitchen and the other spaces that are mostly used by women at the upper courtyard, provides a continuity within the female spatial domain, a continuity between the roof terraces and the female spaces within the house. By this, it puts women in close proximity to each other and consequently may facilitate their contacts. Conversely, in Beni Isguen and Ghardaia, the kitchen, the women's sitting room and the courtyard, are all located at the ground level of the house (see House Plans in figures 2.9 and 2.19). This seems to be a key point in the question about the degree of development of the terrace system, and requires more research. This morphological feature opens up fundamental questions about the relationship between the spatial structure of the settlement as a whole and the internal organisation of the building. Moreover, these morphological differences suggest a relation between the structuring of space and the system of social relations. It suggests a relation of a particular kind between the settlement form and the way in which contacts between and within the sexes are generated and controlled.

- The houses in El Oued have much larger open courtyards than the houses in the Mzab towns or Ghadames; and in some cases, the courtyard is only partly constituted by the rooms (see House Plans in fig. 2.27).

- The examination of the ground plans of the houses in El Oued and their comparison to the houses of Ghardaia, Beni Isguen and Ghadames, suggests a different process of house development. Buildings in El Oued seem to have been generated through an in-fill process. The house must have not been conceived and built as a whole, but rather progressively: first, by delimiting an area by a wall and building few rooms on one side of it; when need arises, a new room is added inside the already bounded area. While in Ghardaia, Beni Isguen or Ghadames, the internal structure of the house and the definite distribution of the different rooms, suggests that the house must have been conceived and built as one complete entity. For example, in Ghadames, the location of the large living room at the first floor and the kitchen at the top floor makes it difficult to believe that the house might have been built following an in-fill or an incremental process (i.e. one floor is built first and later another floor is added and so on until the house reaches its final form).

iii- At the terrace level:

- There is no terrace system in Bellil quarter of Ghadames and in El Oued. In the former, houses have individual terraces used for sleeping during the summer; but these terraces do not connect to one another. In El Oued, the roof of the individual rooms surrounding the courtyards is made up of plaster domes, and therefore totally inaccessible.

- In Beni Isguen and Ghardaia, the connections between the houses at the rooftops take place only at the level of the blocks, although in some cases, passerelles are built over the streets, providing therefore upper floor links between blocks that are separated at ground level. For movements beyond the block, women have to use the street system and in this case, they go about veiled.

- In Ghadames with the exception of Bellil quarter, the pathways at the roofs are systematically built into the system and take the form of a continuous network in the proper sense of the term, in that the areas used for circulation are clearly demarcated by physical boundaries, with "front doors" giving onto them (see Pictures 10 to 17). The spaces used for circulation at rooftops in Beni Isguen and Ghardaia are not explicitly demarcated, but seem to take place haphazardly and wherever possible.

Fundamental differences also exist between these towns from the point of view of space use by men and women. In Ghadames, women use the terraces much more extensively, for everyday socializing and on more formal occasions. Men on their part, use the streets not only for their movements across the town, but also as a meeting place. Men of the quarter congregate outside their working hours, or during the hottest hours of the day in the streets furnished with masonry benches. Some of them go even to the extent to take their siesta on these benches (Yushea B.Q., 1973, p. 94). Women use also the streets at ground level, but they go about veiled and their use is not effective, but only to go to designated destinations. In Bellil quarter where there is no terrace system, women gather outside their homes during the time when men are away at work.

In Ghardaia and Beni Isguen, the use of the terraces is mainly informal. But, the local street (termed locally the "zenka") forms a second stage for contacts between women. The "zenka society" is a space and time-based unit; it depends on both the spatial proximity and the absence of the male-residents from the "zenka". Men, when not emigrants, move out of the local streets and gather at specific areas such as the market, stores, mosques and gardens.

In El Oued, women's space use is limited to the domestic domain. The street is the main meeting place for men, where they congregate in small groups. There appears to be no spatial mechanisms for specifying female contacts above the level of the individual household.

Clearly, the socio-descriptive material shows important morphological differences between the towns, as well as differences in the way in which the settlement space is used by men and women to establish their contacts. The fact that morphological differences are associated with differences in space use suggests a relation between the settlement form and the way in which contacts between and within the sexes are generated and controlled, that is the system of might be loosely called "social solidarities". The understanding of how this is realized through is the main concern of this study. The descriptive material on the social use of space suggests that men and women in these towns may be differently organised in space, and this may have a relation -whether antecedent or consequent is unknown- with the form of the settlement.

The consideration of these differences opens up questions about the relation between spatial order and social relations. The theory of space syntax suggests a conceptual and methodological framework, in which settlements, by virtue of the arrangement and aggregation of the buildings on the ground and the resulting pattern of open space, are seen to engender different patterns of movements and encounter fields with respect to the different social groups (Hillier B., Hanson J., 1984, p. 223-240). Within this framework and in the light of studies on both space structures and movements, a relation has then been established between the spatial configurations of urban forms and their dynamics, such that the structuring of space has been found to relate to the way space is used (SERC Report, 1986, p. 42). On the other hand, spatial order is defined as restrictions on a random process of building aggregation with tacit and intrinsically social rules; while social relations are defined as restrictions on random encounter fields (Hillier B., Hanson J., 1984, p. 33-34). The advantage of this conceptualization is that social and spatial order are seen as intrinsically bound up with each other, but to exist within a life-like framework of more random aspects.

The consideration of the first and second point suggests then a relation between the generative processes of urban forms, the general form they take and the different patterns of space uses. The implication of these suggestions are far reaching, both theoretically and methodologically. Viewed theoretically, the urban systems of interest seem to relate to the social systems of solidarities in three different ways.

First, by establishing strong differentiation between the spaces used by men and women, by means of controlling their degree of accessibility, that is their degree of separation and integration with respect to each other and with respect to the outside. For example, the condition required for the proliferation of the female social activities at the level of the local street, seems to be the relative absence of movements of both, the male- residents and strangers through these streets. Therefore, the distinction of isolated areas from the main activity areas (i.e., the market place) seems to be a key factor and raises the question of spatial differentiation between spaces in terms of their degree of accessibility with respect to the overall fabric.

Second, by imposing restrictions on movements by means of controlling the amount of choice and reducing the potential routes and thereby controlling the degree of interference of one group with another. This particular point addresses itself to the ability of the settlement to allow the female group to meet independently from the male group or prevent this by virtue of the overall arrangement of circulation and movements within the system.

Third, by reducing the "interface potential" between men and women and eliminating the problem of overlap of space uses, by means of providing an exclusive and effective spatial basis for men and women interactions.

From a methodological point of view, the task of the research becomes then two-fold: first, to isolate and describe spatial properties pertaining to the towns; and second, to try to identify the underlying generators in purely formal sense, and describe their related implications on social relations within and between men and women. Two approaches have been adopted for this purpose, one analytical and the other generative.

In the first instance, the study has adopted the theory of space syntax and methodology of settlement description and that is for a number of reasons. The first advantage of the syntax theory in the present context, is it deals with entities or objects and the relations between them. It addresses itself therefore to architectural and urban problems where the main concern is to represent relations between elements rather than concentrate on the external and geometrical properties of the elements themselves. In other words, it deals with relational properties characterising a pattern as a whole. The second most important reason is that the syntax theory is based on a model of urban systems in which the properties of space have an inherent social logic. Finally, this method permits systematic and quantitative comparison which is very crucial for a research project in which the main task is not only to capture and express common similarities and regularities between separate cases but also to identify individual differences.

For the detailed explanation and the fundamentals of the syntax theory, the reader is referred to Hillier's and Hanson's "The social logic of space" (Hillier B., Hanson J., 1984). The analytical aspects of the model used here will be presented in the appropriate places.

The aim of the ensuing chapters becomes then to try to throw light on the system of "differential solidarities" through the analysis of the physical and spatial form of the towns, locally and globally. It is suggested that this will be done in two ways: first, through the analysis of space and simulation of movement (*), that is by looking at the structure and dynamics of these urban systems; and second, through

* Real observational studies for these towns were not feasible mainly because of difficulties encountered locally. But the study includes impressionist data, data on where men sit, and notes on some zenkas' locations.

the generation of such patterns. The relationship between the two might be that the dualistic structure of these towns and its variation might lie in the greater emphasis on male-female differential solidarities, and in the greater localization of the processes of urban formation.

SUMMARY TO CHAPTER THREE:

This chapter has looked at the central issue implied by past studies, that is the principle of separation of the sexes and the privacy concept associated with religious causes . The idea of "separation" is inadequate to explicate the different systems in the different towns for men and women, and the rules of interaction between them, which have both social and spatial realizations. The consideration of the differences observed between the cases in terms of their physical configurations and their associated social uses by men and women, has led to the formulation of a dual hypothesis: that there may be a relation between the structuring of space and the relations between the sexes; and that the structuring of space itself might be seen as a product of a set of spatial rules of buildings aggregation, and these rules might be seen as spatial manifestations of social rules.

PART TWO: SPATIAL ANALYSIS

CHAPTER FOUR: THE SPATIAL ANALYSIS OF THE TOWNS

INTRODUCTION:

Part One of this study has revealed morphological differences between the towns as well as different practices in space use, particularly by men and women. For example, the "zenka society" appears in the towns or town areas where the terrace system is only partially developed, but not where it is either fully developed or absent. This has raised the suggestion that the "zenka" might be related with the spatial nature of the towns. The use of some parts of the street system in Ghardaia and Beni Isguen seems to be possible only if these areas are relatively isolated with respect to the system as a whole from the movements of men. In other words, there could be spatial characteristics inherent in the configurations of the towns which might be related to these differential patterns of space use.

The main question that arises then is to see on the one hand, whether there is a relation between the differential development and appearance of the terrace system, and the spatial structuring of the towns; and on the other, whether there is a relation between the differential space uses observed in these towns and their spatial structure.

The main concern of this chapter is therefore to try to identify spatial characteristics that might relate to the differential space uses, and by this, perhaps show a spatial way of understanding social phenomena that have been presented descriptively. Evidently, this can only be achieved by a full analysis of the town forms.

Two major tasks have been assigned to this chapter. The first task is to analyse the spatial structure of these towns at the local and global level of organisation, against the background of the study of the 75 urban systems (UAS, SERC Report, 1986), in order to establish and identify the distinctive properties of these towns as a group and see the extent to which they differ from each other. The spatial analysis will be carried out at two levels, the analysis of the urban fabric and the simulation of movements within these towns.

The second task of this chapter is to try to look at the relevance of the social potential and implications of the spatial structure suggested by the analysis, in explaining the different social uses of space in these towns by the three social groups, men-residents, women-residents and strangers. By this, this chapter aims to identify the spatial differences that might have critical implications on the way in which the settlement space might be used by these social groups, and particularly by women.

PRESENTATION OF THE ANALYTICAL METHOD AND MEASURES:

The analytical section uses a set of techniques and measures linked together into a theoretical model for the analysis and description of spatial configurations in urban areas. A full report of the model and the results of its application on 75 urban areas and towns has recently become available under the title of "Spatial configuration and use density at the urban level: towards a predictive model" (UAS, SERC Report, 1986).

The method of space syntax employs a graphic technique for representing the spatial pattern of a settlement and a numerical analysis for the evaluation of its syntactic properties. The settlement is viewed as a bi-polar system with the area surrounding the settlement defined as the carrier. This is in the case of Ghardaia, Beni Isguen and Ghadames, the area outside the fortification walls that surround the towns. The other pole comprises the all the buildings that make up the settlement. Space is conceived as being arranged between these two poles.

For the purpose of the analysis, it is the open space of settlements, which is of fundamental importance. It is considered from two points of view and is described in terms of its axial representation. From a theoretical point of view, the open space system is seen as the forum where the inhabitants of the settlement, interface with the strangers. That is the open space system is the interface basis not only between different groups of inhabitants but also between the inhabitants and the strangers. In other words, the open space of the settlement can be seen from the point of view of either the inhabitants or the strangers.

An axial representation considers the open system in terms of its one-dimensional organisation; it refers to the maximum global extension of a space and therefore may be seen to relate to the global organisation of the system. An axial representation of the system will be then the fewest and longest lines that can be drawn in order to cover all of the open surface of the settlement (Hillier B., Hanson J., 1984, pp. 90-91).

The syntax model for the description of settlements uses two types of measures. The first describes the urban systems in purely "static" terms, in the sense that only properties relating to the structuring of space are described; while the second type of measures describes the urban systems in terms of their "dynamics", that is the way in which this spatial fabric is likely to be used as a system of choice for theoretical "moving individuals". Each of these measures can be briefly explained in the following. For full mathematical definitions, the reader is referred to Appendix 2 of the SERC report (SERC Report, 1986) and to "The social logic of space" (Hillier B., Hanson J., 1984, pp. 104-113).

STATIC MEASURES:

The connectivity (CN) measures the degree of connections of axial lines in the settlement, that is the number of other lines to which a given line is connected. The connectivity measure indicates therefore, the degree to which a given line controls access to its immediate neighbours. For the 75 urban systems (*), the mean connectivity is 3.596; and the (mean) maximum is 14.28 (SERC Report, 1986, p. 9).

The real relative asymmetry (RRA) or the integration measure expresses the number of axial steps a given space is away from every other space in the system. A radius-3 integration measures then the distance a space is away from all spaces that are up to three axial steps away, and expresses therefore the importance of spaces at the local level of organisation. When the average RRA values are computed for all spaces of a system, the system is then characterized in terms of the average degree of integration or segregration it engenders. This measure of integration is a two-level relativization of the mean depth values (*); it measures how integrated or segregated a system is from a particular space with how integrated or segregated it could theoretically be, and it relativizes also the

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* The mean depth (MD) of a space gives the average distance (in terms of intervening spaces) from every space to every other space in the network.

The relative asymmetry is given by: RA = 2(MD -1)/K-2; where K is the number of spaces (axial lines) in the system.

degree of integration with respect to size. The integration values for the 75 urban systems vary between 1.532 and 0.563 with a mean of 0.934 (Ibid, p. 9). The most integrated spaces, representing the 10% of the total number of spaces, form the <u>integration core</u> of the system. The importance of the integration core is that it relates the degree to which the "core area" is linked to the surrounding spaces and thus expresses the degree of accessibility of the system especially regarding the easiness or the difficulty of accessing strangers with little knowledge of the system, having only space as reference.

The analysis of the structure of the core will be done in the light of the "deformed-wheel" type, in which the core links a group of spaces in the centre of the system (i.e. "hub") with spaces on the edges (i.e. "rim"), by means of lines connecting in several directions (i.e. "spokes"). A core in which the interior spaces are connected to the outside by means of several lines oriented in several directions is called a "covering core", in the sense that the core covers and expands across the system rather than being confined to a part of it (i.e. SERC Report, 1986, p. 23).

THE DYNAMIC MEASURE OF CHOICE:

The <u>choice</u> (CH) measure expresses the degree of choice that a space represents on all shortest routes from all spaces to all other spaces in the system. It expresses the amount of choice that each space contributes to the system as a whole. This measure (*) predicts the amount of theoretical traffic that passes through each node from every node to every other node in the network, but only for those with a perfect knowledge of the system, such that it is more likely to refer to inhabitants' than strangers' movements.

This simulation exercise provides a basis to discern the potential movement routes and the theoretical traffic inside the towns, regardless for instance, the effect of the attraction of major public facilities such as the market or the mosque.

The connectivity, integration and choice constitute the basic measures of the model. A set of higher order measures have been computed by looking at the relationships between these measures. For instance, the degree of agreement between CN and RRA measures is called the "intelligibility" of the system, and is mathematically measured through the Pearson's product moment correlation. It is suggested that this higher order measure refers to the degree to which the global properties of

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* A space (a) is said to be a choice space for nodes X and Y, if it lies on a shortest path from X to Y, or from Y to X. The choice value of (a) with respect to X and Y is given by: CH (a) = N (X,Y)a / N (X,Y)i; where N (X,Y)a is the number of shortest paths from X to Y or from Y to X which pass through (a); and N (X,Y)i is the number of shortest paths from X to Y or from Y to X which pass through any node i, in either case for D (X,Y) > 1, D being the distance between X and Y (SERC Report, Appendix 2, 1986).

a system can be inferred from its local properties. In other words, it expresses the degree to which the local properties of spaces can be seen as a guide to their properties in terms of the system as a whole. For the 75 urban systems, the average "intelligibility" is about 0.74 (*).

Whereas the degree of agreement between RRA and CH, expressed by the correlation of 1:RA and $\sqrt{CH}$, is termed "<u>global predictability</u>" of the system, and expresses the degree to which the potential use of a space for movement can be predicted or captured from its position in the overall network. It expresses the degree of agreement between the accessibility of a space as a destination from all other spaces in the system and its attractiveness for through-movements to more remote spaces. The correlation between connectivity and choice indicates the degree to which the global movements in the system as a whole could be predicted from the levels of connectivity of a space. This is referred to as "<u>local predictability</u>".

The results of the application of this model suggest certain consistencies in the way in which these measures relate to social factors. The dimension of integration is likely to be more connected with the

* The intelligibility is expressed by the correlation of 1:RA and CN. This measure is strongly affected by the size of the systems, and a relativised version has be computed using the regression line.

movements and access of strangers in the system. This measure expressing the depth of spaces in a system can be considered as an intuitive property, in the sense that the only knowledge required to be remembered when moving is how many steps spaces are distant from each other. In other words, an intuitive picture of the system may be built fairly easily by moving about the system (SERC Report, 1986, pp. 6-7). On the other hand, the measure of choice is more likely to be linked with the movements of the inhabitants of the system. The importance of a space in terms of the degree of choice it represents on all shortest routes from all spaces to all other spaces in the system, is a "much more difficult property to intuit", but depends on more knowledge of the system not simply in terms of the number of steps separating spaces from each other, but also of all the possible routes between spaces (Ibid, pp. 6-7). Such a knowledge of the spatial configuration can only be acquired by the inhabitants who live in the system, and are "aware" of all the shortest routes, when moving towards particular destinations. In the present context, because of the difference in the degree of mobility between men and women, the dimension of choice may be seen to represent a more lifelike picture of the movements of the male-inhabitants.

The synoptic studies of the SERC report have shown that the spatial structure of urban systems from different parts of the world are characterized by great variations not only in terms of the basic measures but also in terms of their statistical interrelations. These variations are of a great magnitude to the point of suggesting that they may be a product of different types of social constraints imposed on the way the urban systems have been generated. This particular point will in fact make the main concern of Part Three of this report.

However, some general conclusions have been derived from the synoptic studies of the SERC report. These can be summarized in the following. The measure of integration has proved to be the best predictor for real movements of people (SERC Report, 1986, pp.39-40). In other words, the results of the field studies have shown that the encounter rate and real movements are governed by the integration of the system; and that the real predictibility of the system is governed by the level of intelligibility. Therefore, a relation has been shown to exist between the spatial structuring of urban systems and their dynamics.

The spatial analysis of Ghardaia and Beni Isguen is carried out on three different versions of the ground plans. First, the towns will be looked at as closed systems with the defensive internal walls and the adjoining peripheral spaces. Second, the towns will be analysed without taking into account these peripheral streets; and finally, the towns will be looked at with the connections of the gatelines (*) to the outside considered as a single entity. The idea underlying the various states of representation of the towns is that the fortification walls and the resulting peripheral streets with the town gates are built for defence purposes; in other words, their main function is to control access of strangers to the town. For this reason, it is suggested that if the system is to be understood as a forum for interfacing the inhabitants and the strangers, then the analysis which takes into consideration the town walls with the spaces inside them and the connections of the gatelines to the outside would be more relevant. Whilst, if the system is to be understood as an interface between the local population only, the inhabitants, then the analysis of the system without the effect of the peripheral streets would be more appropriate.

For Ghadames and El Oued, only two versions are considered, since for El Oued, the fortification walls are non-existent; and for Ghadames, although the town is also protected by defensive walls, these surround the whole oasis, gardens and palm groves included. The walls are not therefore a town feature that enters directly in the constitution of the street system.

For notational simplification, some abbreviations will

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* A gateline refers to the axial line that runs through the gateway of the town towards the outside of the fortification walls, and directly links the outside to the interior of the town.

be adopted in reference to the different analyses. G1 will refer to the system of Ghardaia as analysed with the peripheral spaces that are inside the town walls; G2 will refer to the system analysed after the removal of these peripheral spaces and G3 to the system analysed with the connections of the gatelines of the town to the outside.

Similarly, BI1 will refer to Beni Isguen as analysed with the defensive walls and the adjoining peripheral spaces, BI2 will refer to the system analysed after the removal of the peripheral spaces and BI3 to the system looked at with the connections of the gatelines to the outside. Ghad1 and EO1 will refer to Ghadames and El Oued respectively analysed as closed systems, that is without the connections of the towns to the outside; and Ghad2 and EO2 will refer to the systems with their links to the outside.

Only the distributed system (*) of the spatial configurations of the towns in terms of their axial representations, are used in the following analysis. Analytic measures have also been computed using both the distributed and non-distributed structures of the street systems and the results suggested no substantial differences from the systems analysed only on the basis

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* A relation between two spaces A and B is said to be <u>distributed</u>, if there is more than one independent route from A to B. Conversely, it is <u>non-distributed</u> if there is only one route from A to B, i.e. a dead-end (Hillier B., Hanson J., 1984, p.94). A distributed system is then a system where all spaces are linked at least to two other spaces.

of the distributed structure.

The analytical procedure adopted for the spatial analysis can be summarized as follows:

i- a numerical analysis of the towns taken as a group is carried out. This aims at the examination of the means and distribution of the spatial measures, as well as their statistical derivatives for the whole sample and to see how far the spatial measures correlate with each other and with the size of the systems given by the number of the axial spaces.

The sample consists of the four towns (Ghardaia, Beni Isguen, Ghadames and El Oued), the systems at different stages of growth for Ghardaia and Beni Isguen, and four different parts of Ghadames. This makes a total of 12 systems, with size varying between 12 and 320 spaces.

In addition to this, a detailed examination of the numerical properties of each case study is undertaken, using as a basis for the analysis the ground plans of the towns at different phases of expansion and according to the three versions of representation. The analysis of the pattern of growth of the towns or the analysis of their parts, concerns only Ghadames, Ghardaia and Beni Isguen. For El Oued, this section has been omitted for two reasons. First, the settlement is already very small and seems to be at its earliest phase of development; and second, no information or reference has been found concerning its historical development. However, from the descriptive material presented in Part One, the development of the entire region of the Souf, seems to follow a consistent pattern which takes the form of numerous but small settlements scattered all over the region. The availability of agricultural land and water, and the method employed in the cultivation of palm trees, seem to have contributed in limiting the size of these villages (Bataillon C., 1955, p. 48).

ii- A detailed analysis of the integration core and the segregated spaces for each case considered locally and globally, and for each of the different states as specified above, is undertaken.

iii- A spatial analysis of simulated movements for each case study will be carried out. This includes the analysis of the internal movements given by the choice and the analysis of the interface between the movements generated internally and those originating from the outside, which are given by the correlation of the quantities of choice and the random simulated journeys from the gatelines. By this, it is aimed to explore the pattern of random journeys from the outside and see how far they correlate with choice and perhaps, conjecture about the type of interface that is likely to take place between the movements generated internally, that is the movements of the inhabitants, and the movements originating from the outside, that is the movements of the strangers.

iv- The analysis of the terraces will be then undertaken in an attempt to see how far the syntactic properties can amplify the morphological differences observed in their configurations as described in Part One.

v- The last section of this chapter opens up a discussion about the possible consequences of these spatial systems as described syntactically, on the way in which the town fabric and its global organisation might be used by the three social groups, and perhaps show a spatial way of explaining the differential patterns of use that have been presented descriptively. By this, this section aims to look at the possible social implications of the spatial properties.

The chapter ends up by raising the question to be broached in the last part of the study which asks in what precise way can the spatial structure of the towns as described syntactically, be seen as a product of socio-spatial rules?

THE SPATIAL DESCRIPTION OF THE TOWNS FABRIC:

The primary task of this section is then to carry out a numerical analysis of the towns taken as a group, against the background of the studies at the Unit for Architectural Studies, University College London.

The analytical measures are generated on the basis of the plans of the towns represented in terms of their axial relationships, that is the least set of lines which cover all of the open surface. Each line is assigned a number and a matrix of the connections between the lines is prepared. The information on connectedness will serve as the input data for the computer analysis. The axial maps for the four settlements are presented in figures 4.1 to 4.4 (4.1 Ghadames, 4.2 Ghardaia, 4.3 Beni Isguen, 4.4 El Oued).

Some differences and similarities can be seen from this graphic representation. For example, the position of the longest line varies in the four settlements. In Ghardaia, the longest lines (numbered 199 in fig. 4.2) links directly the market place to the outside. In Beni Isguen, the longest line (numbered 260) is located away from the market place and forms an edge at the periphery of the settlement. In Ghadames, there is no strong line which is markedly distinguishable in terms of length from the other lines of the system. In El Oued, the two longest lines (numbered 3, 8) criss-cross at the centre of the settlement.

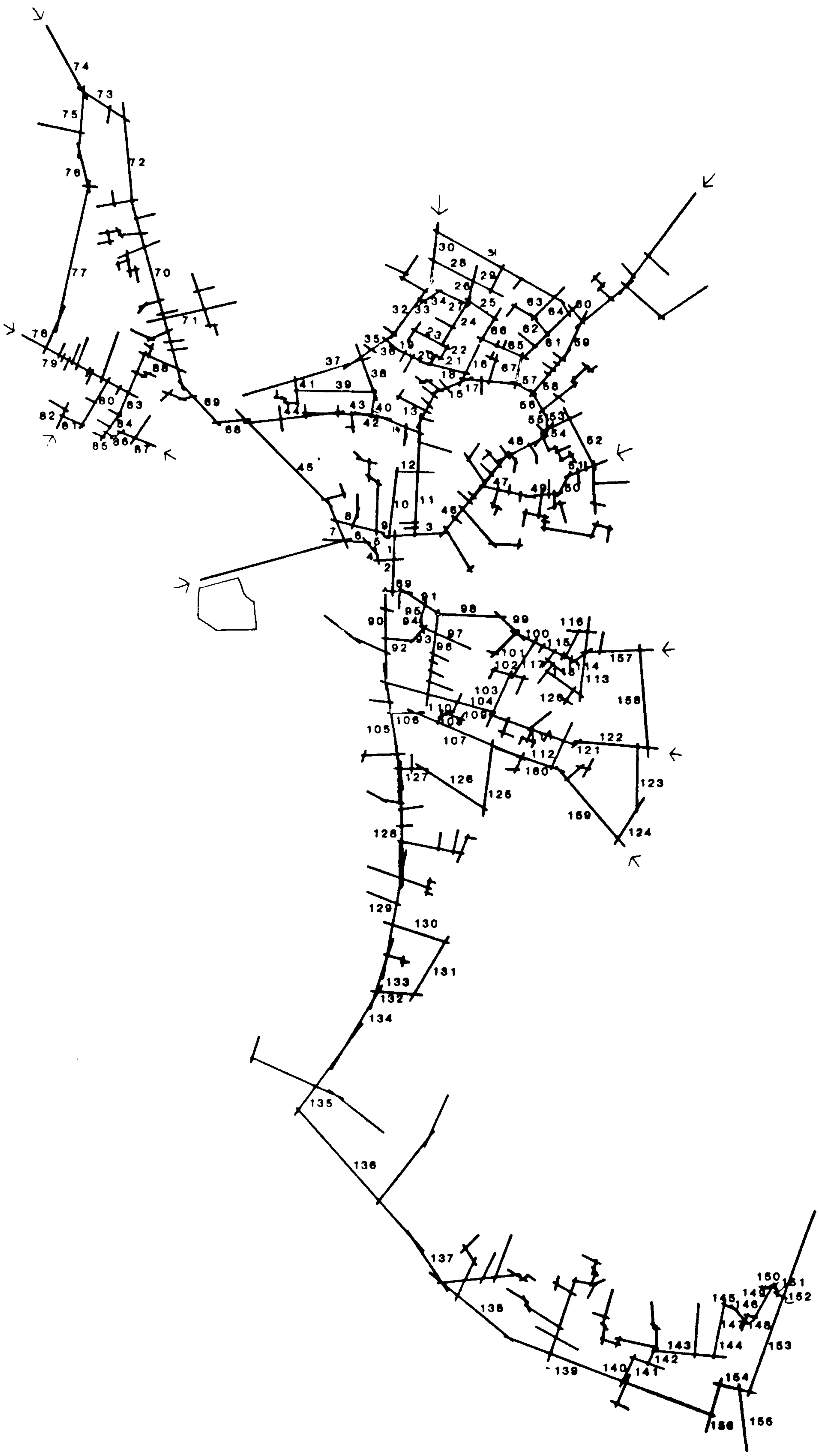

FIG. 4.1 : GHADAMES, AXIAL MAP

the plan of the town at a scale of 1:1000).

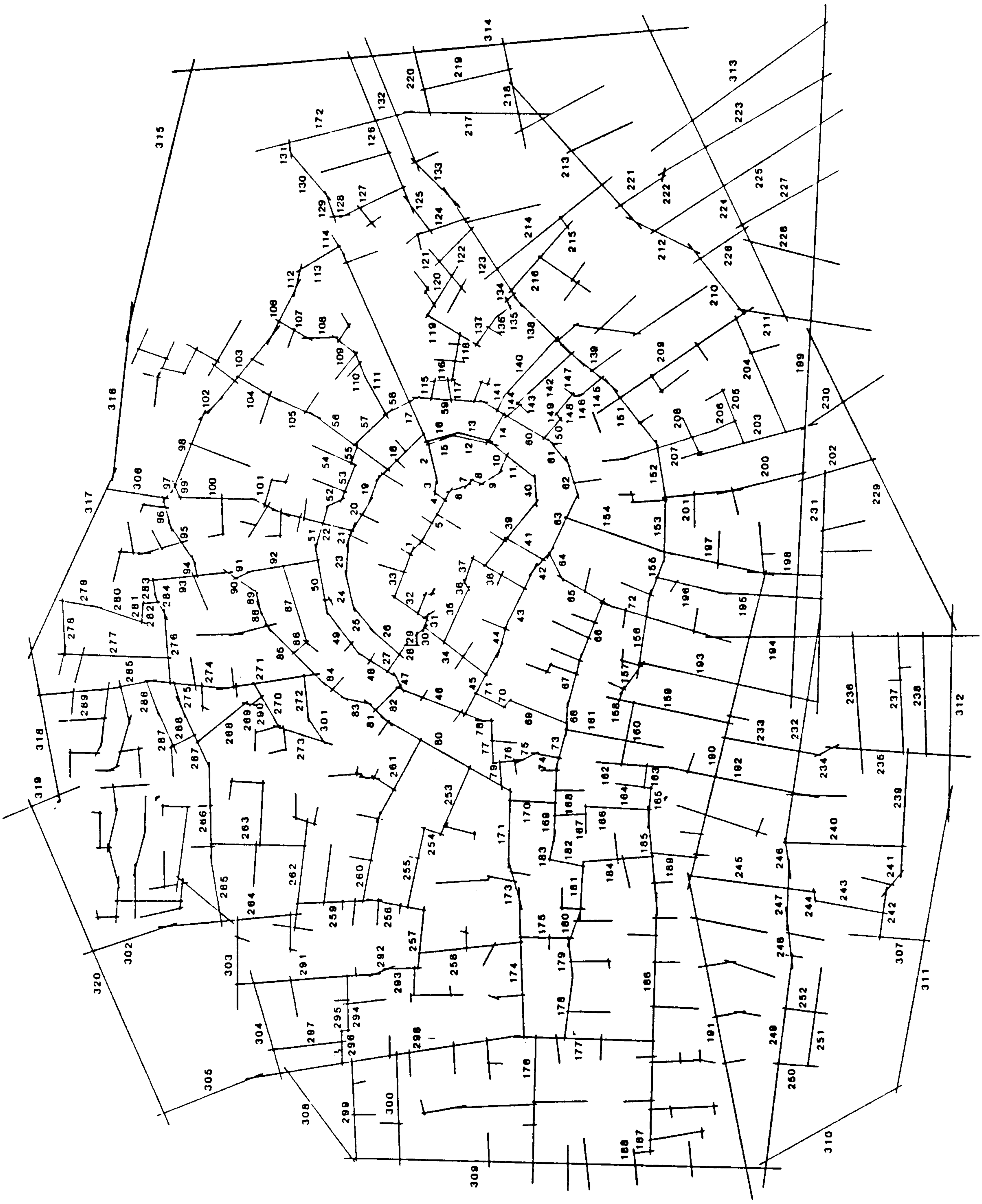

FIG. 4.2 : GHARDAIA, AXIAL MAP

of the plan of the town at a scale of 1:1000).

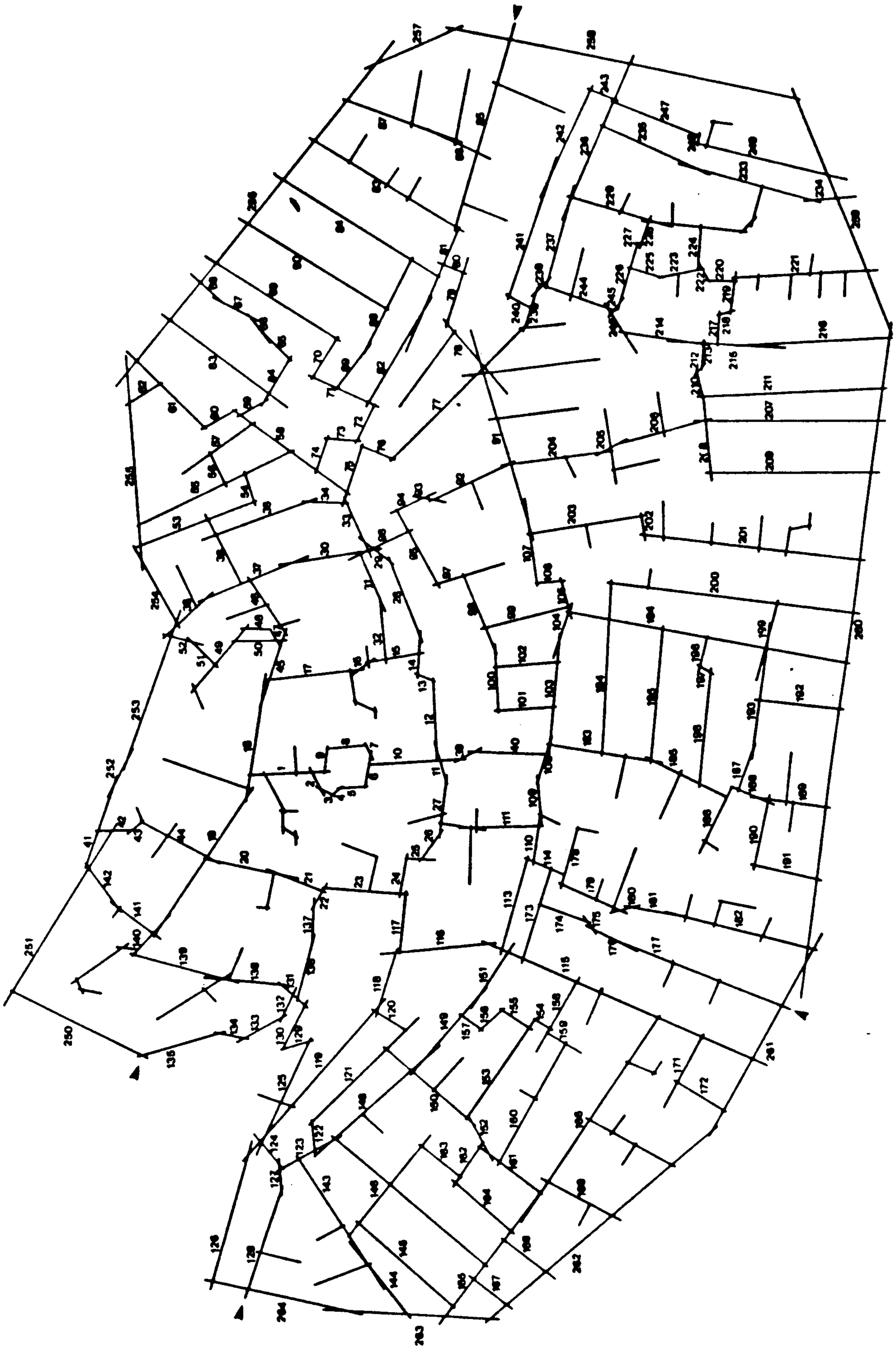

FIG. 4.3 : BENI ISGUEN, AXIAL MAP

3: The axial map has been drawn on the basis of the ground plan of the town at a scale of 1:1000).

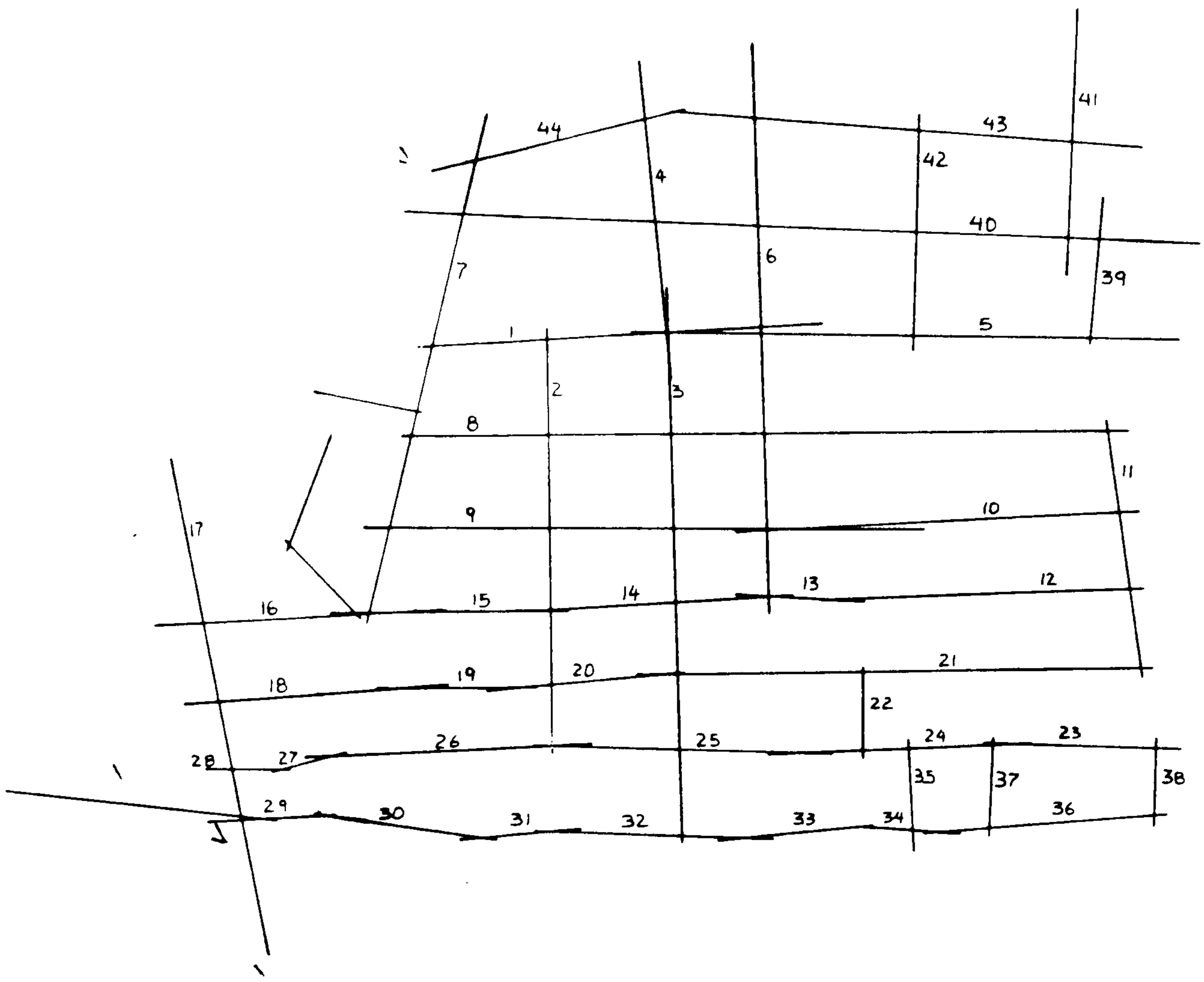

FIG. 4.4: EL OUED, AXIAL MAP

	MEASURES FOR SAMPLE OF CASE STUDIES		MEASURES FOR 75 URBAN SYSTEMS(*)	
	CN	RRA	CN	RRA
MEAN (K)	2.619 (-0.017)	1.599 (0.424)	3.596 (0.197)	0.934 (-0.053)
MAX. (K)	6.000 (0.763)	2.362 (0.272)	14.280 (0.765)	1.532 (0.027)
MIN. (K)	1.889 (-0.590)	1.155 (0.517)	1.133 (-.153)	0.563 (-.059)
ST.DEV.	0.916	0.273	2.208	0.203

TABLE 4.1: MEASURES FOR THE 12 CASES TAKEN AS A GROUP AND THE 75 URBAN SYSTEMS, AND CORRELATIONS WITH SIZE.

Table 4.1 gives the means for the basic measures and their correlations with size for both the whole sample and the 75 urban systems. (SERC Report, 1986, p.9). It shows markedly different characteristics:

- The mean connectivity of the sample (2.619) is much lower than the average for the 75 urban systems (3.596), and does not correlate with size (as in the 75 cases).

- The maximum connectivity for the whole sample, which is the mean of all maximum values, is only 6.00 com-

* K refers to size and St. Dev. to standard deviation of the RRA measures. The figures in brackets represent the correlation coefficients of K with the other measures. The average K of the systems is 112.

* Source: SERC Report, 1986, p. 9.

pared to 14.28 for the 75 urban systems, and positively correlates with size as in the 75 urban systems.

- The mean integration of the sample (1.599) is much lower (*) than average (0.934 for the 75 urban systems); and does correlate but only weakly with size (0.424), in contrast to the 75 urban systems where there is no correlation (-0.053). This means that the systems under examination tend to become more segregated as they grow larger.

- The maximum integration (2.362) does correlate with size, but only very weakly (0.272), compared to the 75 urban centres in which there is no correlation (0.027). The maximum integration for the 75 urban systems is in fact equal to the mean of the towns under study.

- The minimum integration (1.155) which remains much lower than the mean for the 75 urban systems, behaves in the same way as the mean integration.

* A low value of RRA measure indicates a strong level of integration (see Appendix2 of SERC Report, 1986).

	MEASURES FOR THE WHOLE SAMPLE			MEASURES FOR THE 75 URBAN SYSTEMS (*)		
	1:RA/CN	1:RA/RCH	CN/CH	1:RA/CN	1:RA/RCH	CN/CH
MAX.	0.577	0.792	0.740	0.949	0.924	0.928
MEAN	0.289	0.496	0.379	0.686	0.740	0.768
MIN.	0.078	0.219	0.256	0.356	0.316	0.122
r:K	-.641	-.695	-.410	-.552	-.587	-.132

TABLE 4.2: SECOND ORDER MEASURES FOR THE 12 CASES AND FOR THE 75 URBAN SYSTEMS.

The second order measures for the sample and for the 75 urban systems are set out in Table 4.2 which shows striking differences between the two sets of measures. The key results are:

- The average intelligibility for the whole sample (0.289) is by far much lower compared to the 75 urban systems (0.686), and strongly correlated but negatively with size. This means that the intelligibility of the systems weakens with regard to size, as the 75 systems.

- The global predictability is again of a lower range (0.496) when compared to the 75 urban systems (0.740), and strongly correlates with size (-0.695); and indicates that these systems when considered as a group, become less predictable as they grow bigger.

* Source: SERC Report, 1986, p. 11.

- The local predictability for the sample (0.379) is also much lower than it is for the 75 urban areas (0.768), and does correlate but only weakly with size.

Clearly, these measures of the towns considered as a group already indicate distinctive properties of the spatial fabric of the towns under study. They indicate a highly segregated fabric which is less intelligible and less predictable than the 75 urban systems, and which is strongly affected by size.

	K	1:RA/CN	1:RA/RCH	CN:CH
MEAN CN	-0.017	0.435	0.139	0.004
MAX. CN	0.763	0.151	-0.384	-0.218
MEAN RRA	0.424	-0.751	-0.626	-0.591
(cont log K)	-	(-0.563)	(-.348)	(-0.435)
MAX. RRA	0.272	-0.473	-0.566	-0.495
(cont log K)	-	(-0.256)	(-.416)	(-0.370)
MIN. RRA	0.517	-0.898	-0.570	-0.546
(cont log K)	-	(-0.802)	(-.218)	(-0.348)
1:RA/CN	-0.641	-	0.543	0.560
(cont log K)	-	-	(-.018)	(0.347)
(cont RRAMEAN)	-	-	(0.143)	(0.218)
1:RA/RCH	-0.695	0.543	-	0.695
(cont log K)	-	(-.018)	-	(0.579)
(cont RRAMEAN)	-	(0.143)	-	(0.517)

TABLE 4.3: SYNOPTIC CORRELATIONS FOR THE TOWNS UNDER STUDY (12 CASES).

Table 4.3 summarizes the degree to which the analytic

* (cont log K) refers to the partial correlation between two measures when controlling for size given by log K.

measures relate to each other, controlling for log K or for integration. The results are:

- There is no strong correlation between the connectivity and the second order measures.

- The integration correlates strongly with intelligibility (-0.751), weakening to (-0.563) when log K is controlled for, which is the opposite way round to the 75 urban areas (-0.527 becoming -0.714 when log K is controlled).

- The integration does correlates with global predictability (-0.626), but strongly falls when size is controlled for (-0.348), another different result from the 75 urban systems where there is no correlation (0.0024 becoming 0.034 when log K is controlled for).

- The integration also correlates with local predictability (-0.591) but not to the same degree as in the 75 systems (-0.716 improving to -0.743 when log K controlled for), and falls when log K is controlled (-0.435).

Table 4.3 shows also that there is a positive correlation between intelligibility and predictability (0.543) which disintegrates entirely in both when log K and mean RRA are controlled, contrarily to the 75 systems where the correlation between the two measures improves strongly when mean RRA is controlled, and suggests that this change may denote a key property of the systems under study and the way they grow.

But, the idea of settlement type implies the existence of a set of properties that remains constant across the sample of different cases and the above measures do not show that, but were merely derived by calculating the means of the specific values for each case, indicating only that without any information concerning the variations and the differences between the cases.

For this purpose, the following sections set up a detailed examination of the measures for each town at different stages of development, and for each version of the settlement.

CASE ONE: GHADAMES

	GHAD1	GHAD2
NBER OF SPACES	160	161
MEAN CN	2.50	2.54
MAX. CN	5.00	5.00
MEAN RRA	2.29	1.47
MAX. RRA	4.37	3.05
MIN. RRA	1.36	0.80
ST. DEV.(RRA)	0.65	0.41
1:RA/CN(1*)	0.46	0.49
R INTEL(2*)	-0.19	-0.16
1:RA/RCH	0.46	0.52
R. PRED.	-0.24	-0.18
CN/CH	0.46	0.56

TABLE 4.4: GHADAMES, MEASURES FOR THE TWO VERSIONS

The above table shows no variation in the mean and the maximum connectivity, but a clear improvement in the integration of the system when connected to the outside. These remain however well below average. The intelligibility is very low for both versions. The level of global and local predictibility is also low and improves a little in Ghad2.

	MAZIGH	BELLIL	WAZIT	DARRAR	WHOLE
NBER OF SPACES	12	20	50	67	160
MEAN CN	2.17	2.15	2.60	2.57	2.50
MAX. CN	3.00	3.00	5.00	5.00	5.00
MEAN RRA	1.37	1.93	1.32	1.45	2.29
MAX. RRA	1.85	2.68	2.52	2.05	4.37
MIN. RRA	1.21	1.42	0.80	1.02	1.36
ST. DEV.	0.18	0.29	0.33	0.24	0.65
1:RA/CN	0.76	0.67	0.61	0.55	0.46
R.INTEL.	-0.10	-0.15	-0.15	-0.17	-0.19
1:RA/RCH	0.87	0.89	0.71	0.79	0.46
R.PRED.	-0.04	+0.01	-0.09	+0.01	-0.24
CN/CH	0.69	0.86	0.71	0.70	0.46

TABLE 4.5: GHADAMES, MEASURES FOR THE DIFFERENT PARTS.

Table 4.5 sets up the analytic measures for the four

1* It must be noted that the mean for correlation coefficients (i.e. 1:RA/CN) for the whole sample have been derived from the squared values of the variances, in order to overcome the problem of negative coefficients. This is why the means for the towns taken as a group are much lower than the values computed for each case separately.

2* In the tables, R INTEL. refers to the relative intelligibility which expresses of the intelligibility of the system in question against the value predicted by the synoptic studies of the 75 areas for a system of a similar size. Similarly, R PRED. refers to the relative predictibility.

quarters of the town. The results show that:

- The mean connectivity of the small areas varies but not strongly (from 2.15 to 2.60) and takes the lowest value in Bellil, the quarter without the terrace system, but remains in general well below average.

- The maximum connectivity is also very low in the smallest areas (3.00 in Mazigh and Bellil), and increases in the larger quarters; but in all cases it remains by far below average.

- In all areas, the mean integration remains very low; it is the lowest in Bellil quarter (1.93).

- The intelligibility is below average in all quarters and strongly falls when the areas are put together.

- The predictability given by the integration is in general, about average in the four small systems (although in Wazit, it is below average, -0.09), and strongly falls when these are combined into the larger system.

- The predictability given by the connectivity is about average in the small systems, but becomes much weaker in the system seen as a whole.

- The integration cores for each of the small areas are presented in figures 4.5 to 4.8.

<u>In Darrar</u>, the three best lines in terms of integration form a linear sequence running from the southern peri-

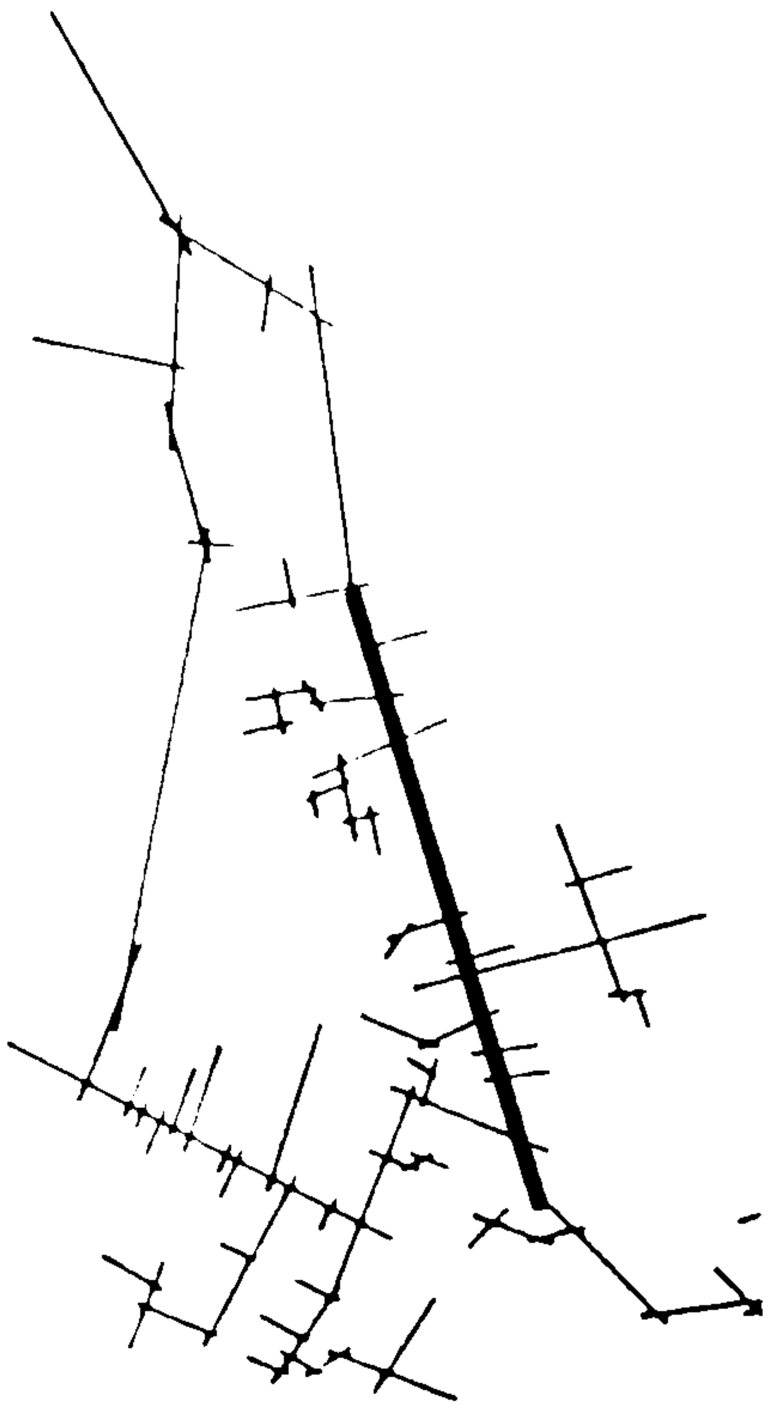

FIG. 4.7 : GHADAMES, INTEGRATION CORE OF MAZIGH

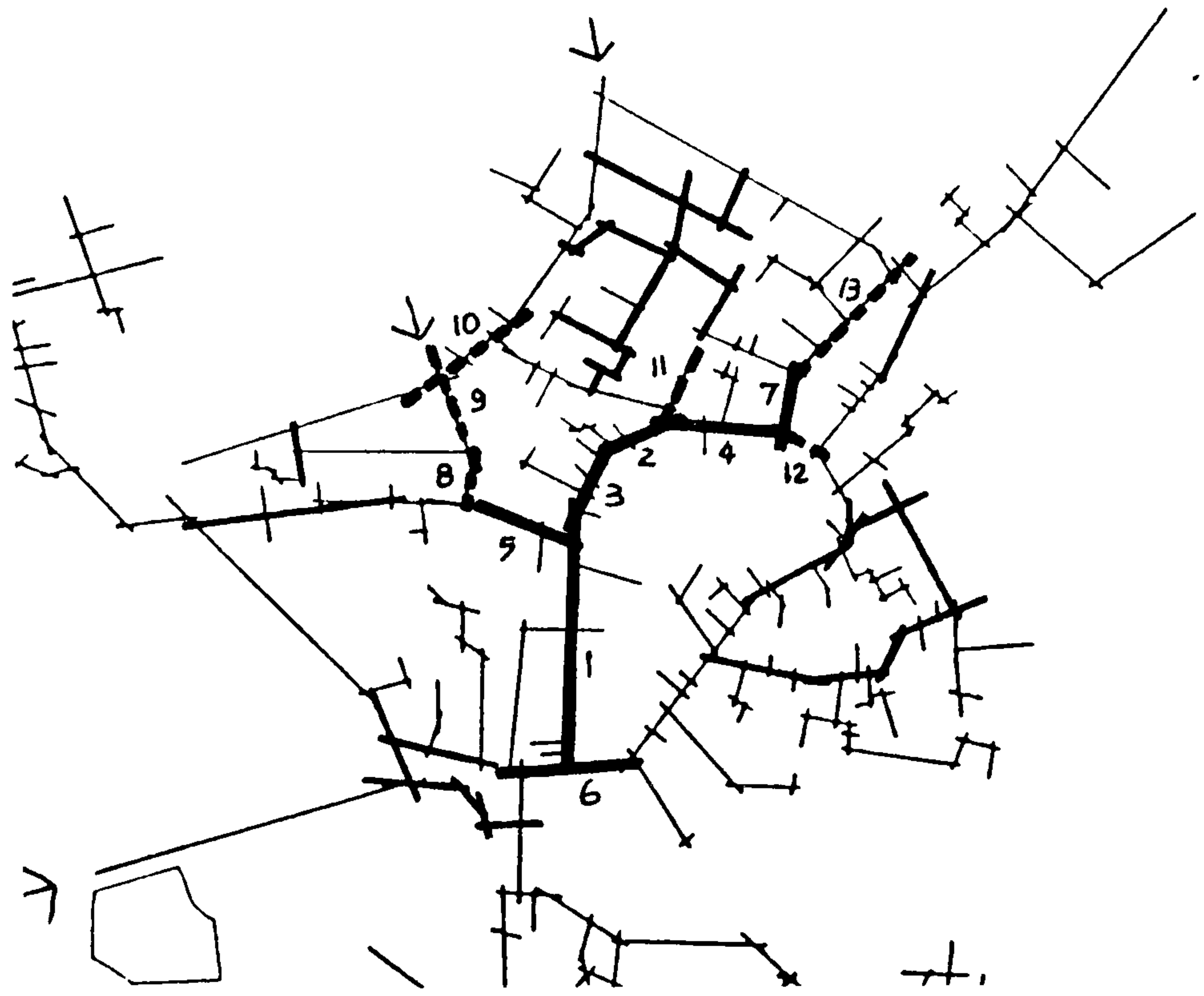

FIG. 4.5 : GHADAMES, INTEGRATION CORE OF DARRAR

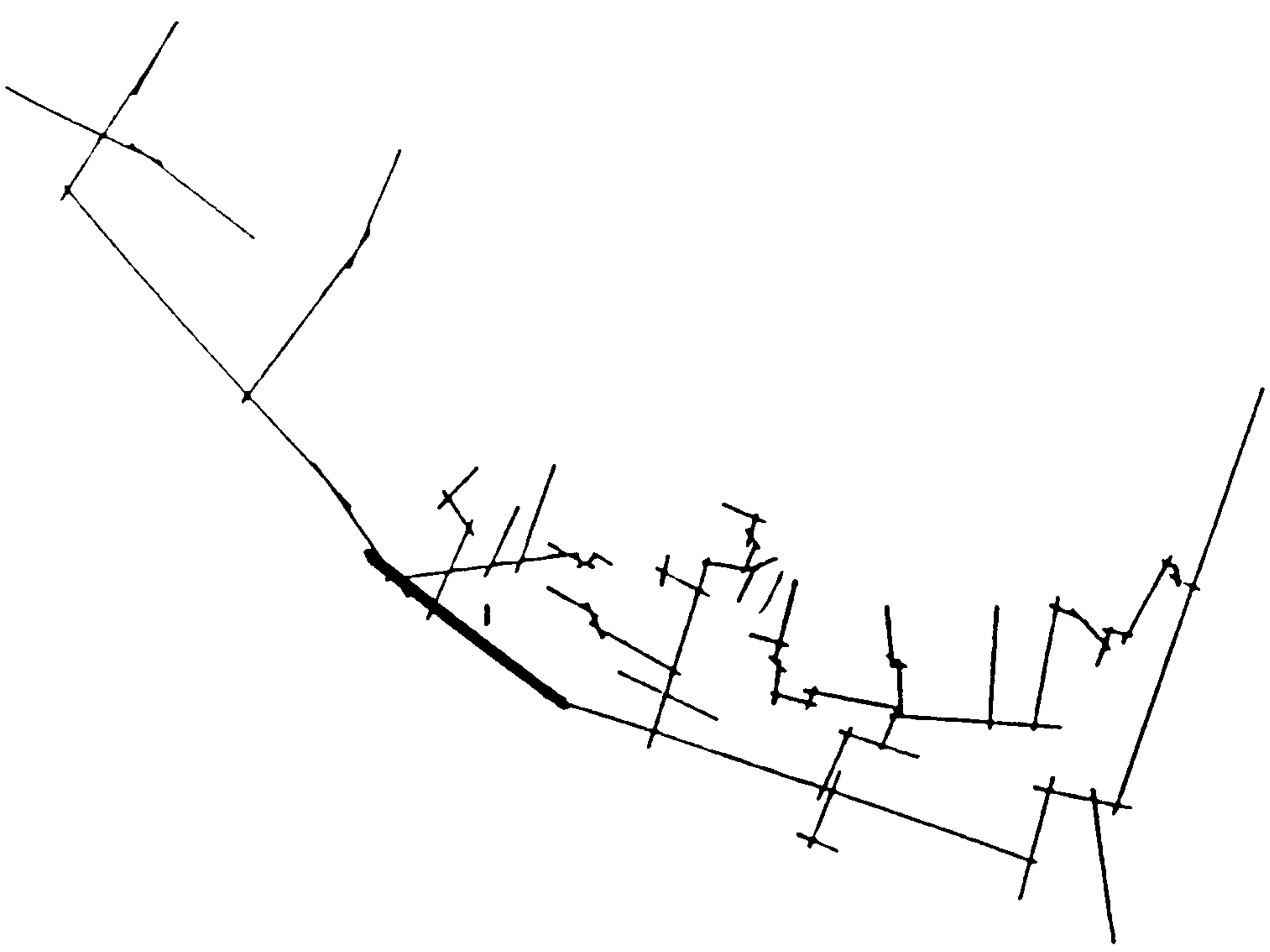

FIG. 4.8 : GHADAMES, INTEGRATION CORE OF BELLIL

FIG. 4.6 : GHADAMES, INTEGRATION CORE OF WAZIT

phery towards the north, and linking the market square and the main mosque to the rest of the area. The integration core tends to form a continuous structure expanding in several directions across the quarter. An increase in the percentage (15%) of the most integrated spaces that constitute the core reveals a structure which approaches the covering core type, that is a core with a group of linked spaces at the interior of the area, connected to the outside by means of several other lines. The best lines in terms of integration run also along the streets that are furnished with masonry benches. The most segregated spaces form four clusters around the integration core.

For Wazit, the integration core concentrates in the area near the mosque and expands into two directions, one southerly along the "Tingesin" street and the other easterly and penetrates deep into the area (see Integration Map, fig. 4.6). The core presents as well a structure which tends to cover the whole quarter, and links to the outside in three main directions. It also develops along the streets that are equipped with masonry seats. The most segregated spaces form two main clusters on the edges of the area.

For Mazigh, the integration core takes a linear shape running along the main road of the quarter which is also equipped with built-in seats for men.

For Bellil, the integration core constituted only by two lines runs along the peripheral street. The quarter's mosque is located on the core.

Only Darrar and Wazit contribute strongly to the constitution of the integration core of the whole system. When the cores of these two areas are combined together, the resulting structure bears strong resemblance to the integration core given by the analysis of the system taken as a whole (see fig. 4.9). A detailed analysis of the system as a whole will follow.

The above results show a clear tendency towards the isolation and localisation of the smaller areas through the way in which the system distributes its connectivity, which creates an overall strong segregation. The whole spatial structure seems to be geared towards the emphasis of the local areas. The fact that both the mean and the maximum connectivity remain constant throughout the growth process suggests that the system when expanding, does not introduce more order by adding more connections to some spaces, while for example, retaining the overall degree of connectivity constant, as observed in the 75 urban systems study (SERC Report, 1986, pp. 9-10).

PATTERN OF THE INTEGRATION IN GHADAMES:

The spatial analysis of Ghadames in terms of integration reveals some interesting properties. Figure 4.9 shows the order of integration of the 10% most integrated lines. The first integrator runs on the

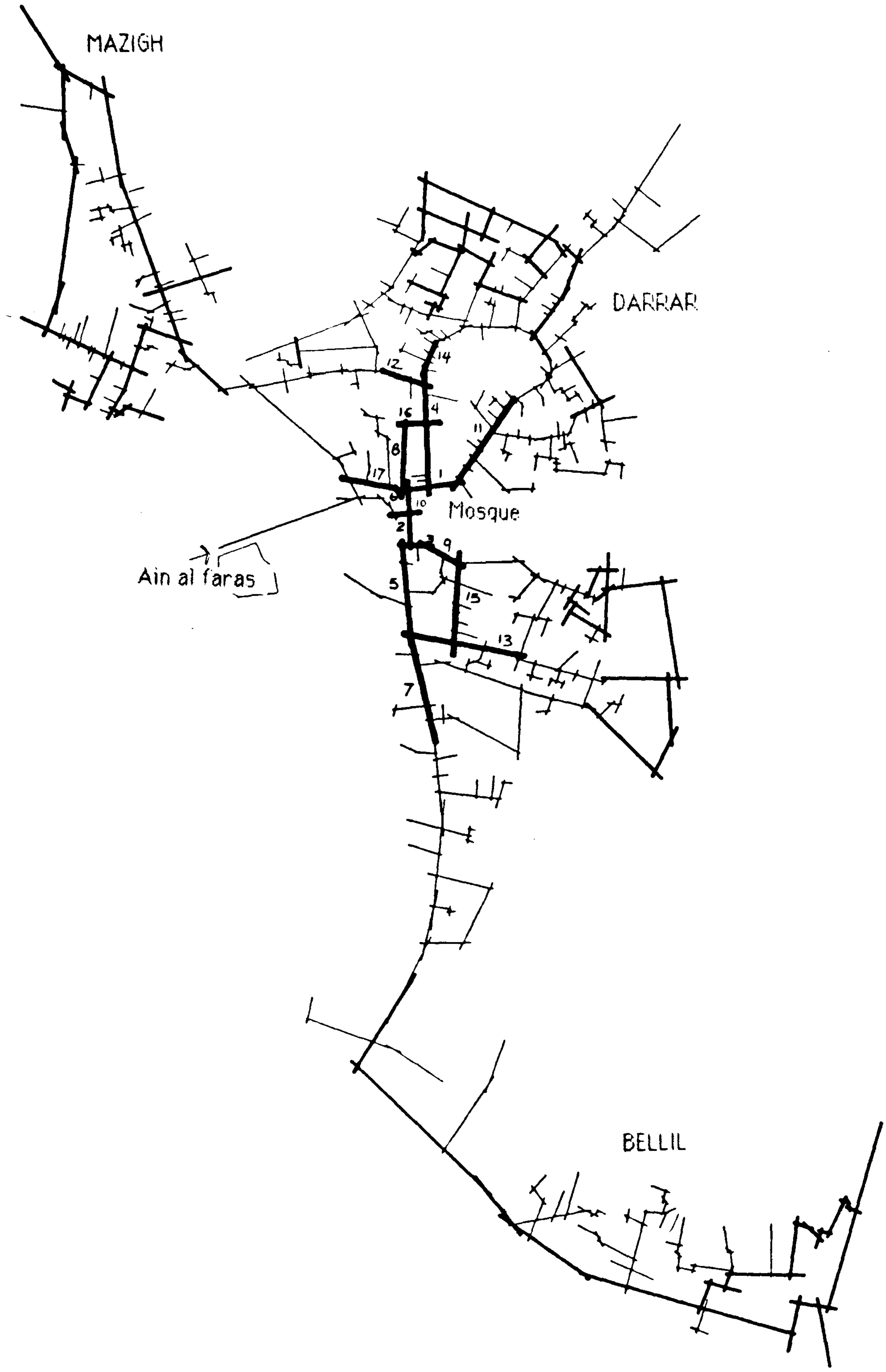

FIG. 4.9 : GHADAMES, INTEGRATION CORE (GHAD1)

INTEGRATION CORE

50% SEGREGATED SPACES

Walid side of the town, along the main mosque. The second integrator traverses the market square and links together the two parts of the settlement; the third and the fourth most integrated lines are located in Darrar and Wazit quarters respectively. The three most integrated lines intersect at the market square.

The most integrated spaces are carefully located on the edge of the town, though the linear form of the settlement disguises this position. They form a continuous structure, running north-south across Darrar and Wazit. This integration core traverses the market square, Suq El Gaddus, where the two main mosques are located, Jama'a El Atik for the Walid and Jama'a Yunes for the Wazit. These town facilities are located at one extremity of each quarter, and constitute the only common ground between them. The integration core penetrates only a little into the quarters, but without traversing them. The most integrated spaces form also, two rings on either side of the market square.

The most segregated spaces, on the other hand, form four separate clusters, in each of the four distinct parts of the town. Most of the lines (if not all) of the axial systems of the areas Mazigh and Bellil, form part of the segregated spaces. These are as well in geographical terms, rather remote from the market square and the two main mosques. The most segregated spaces in Darrar are located on the north-eastern periphery of the quarter. In Wazit, they are on the eastern periphery.

From this analysis, it appears that in Ghadames, the market square and the area around the two main mosques form the major elements in terms of integration for the whole system. Figure 4.10 shows the integration core resulting from the analysis of the system connected to the outside, which consists of all the gatelines of the town, mainly because the "outside" is now the most integrated element. The core presents then a discontinuous structure which is located away from the town facilities.

On the other hand, the radius-3 integration core shown in figure 4.11, includes most of the spaces of radius-n integration core (GHAD1), and also some of the spaces of the integration cores of Darrar and Wazit.

THE ANALYSIS OF SIMULATED MOVEMENTS IN GHADAMES:

The choice structure:

The mapping of the strong choice lines shown in figure 4.12, reveals a linear structure running north-south through the two quarters, Darrar and Wazit. The best three lines in terms of choice intersect at the market square and link together the two quarters, while the fifth and the sixth run from the central area where the two mosques are located, and penetrate into the two quarters. None of the spaces of Bellil and Mazigh, form part of the strong choice structure.

FIG. 4.10 : GHADAMES, INTEGRATION CORE (GHAD2)

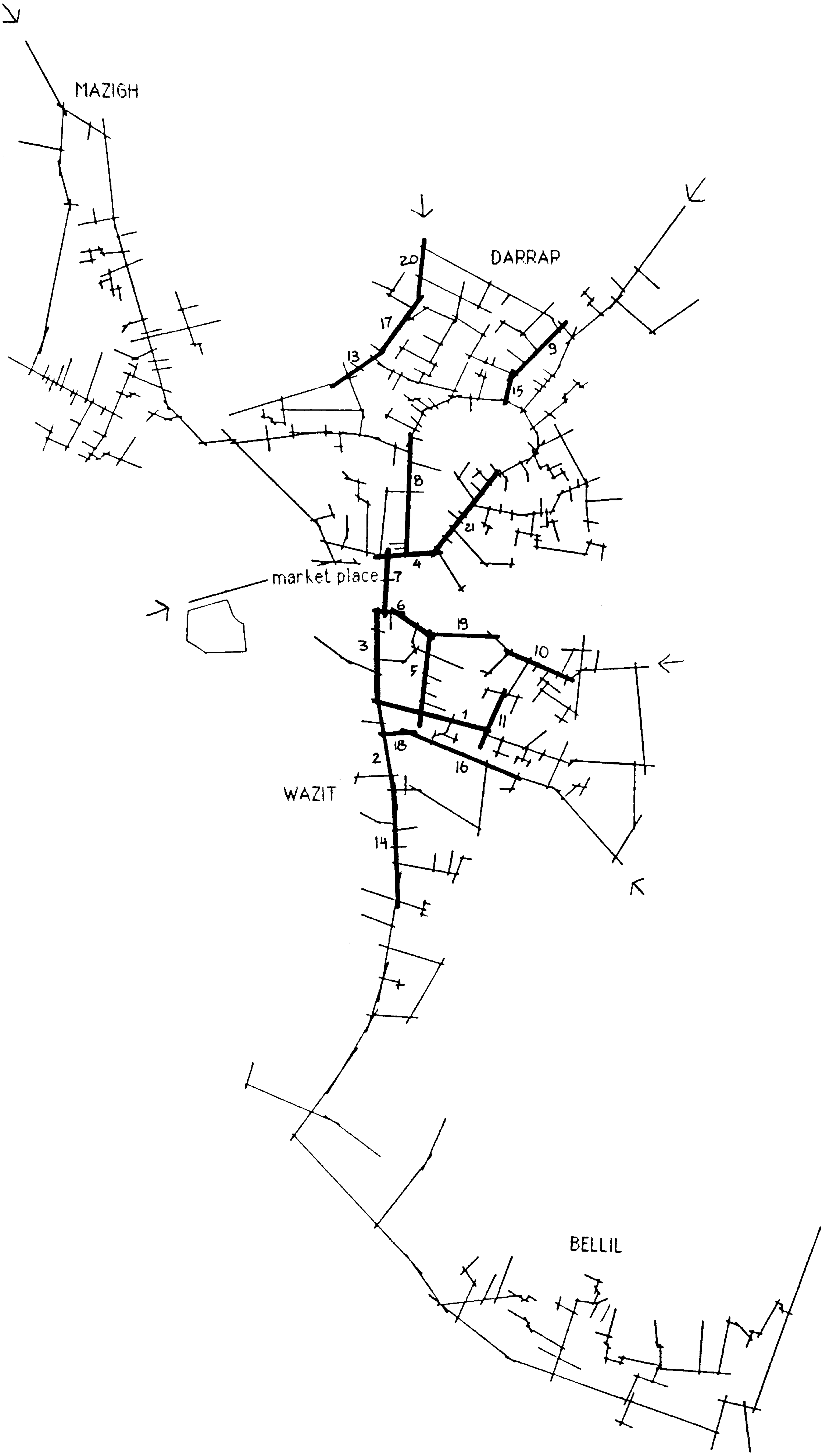

FIG. 4.11 : GHADAMES, RADIUS-3 INTEGRATION CORE

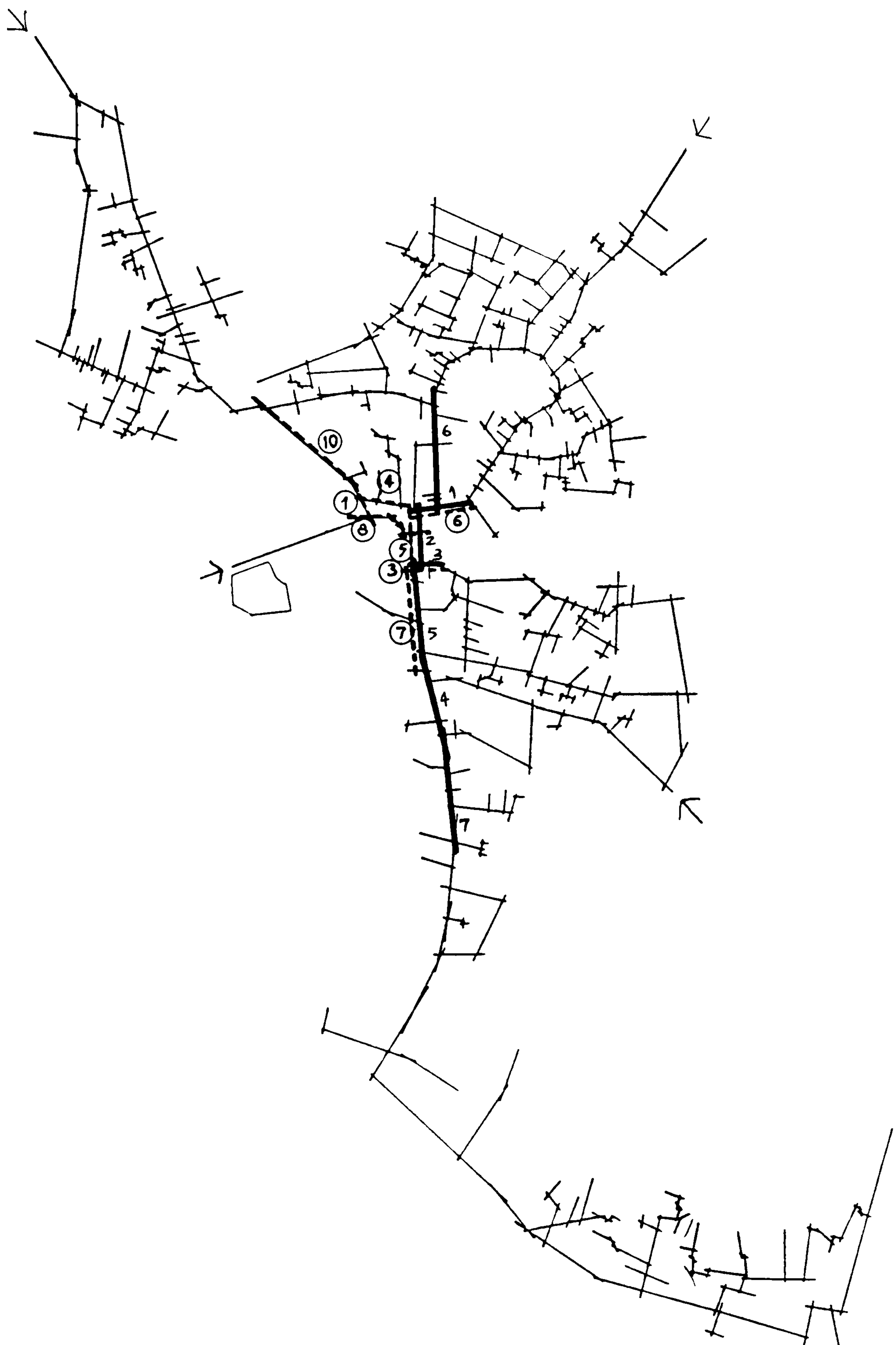

FIG. 4.12 : GHADAMES, THE CHOICE STRUCTURE

CHOICE STRUCTURE

RANDOM JOURNEYS FROM OUTSIDE

The comparison of the choice and integration structure shows a strong correspondence. The three most integrated spaces are also the three strong choice lines; the fourth and the fifth in terms of integration are the sixth and the fifth in terms of choice. From this follows the suggestion that the integration and the choice structure and especially the town square where the market is held and where the religious buildings stand, form the main meeting point for the male inhabitants of the different social groups that constitute the population of Ghadames. It is also there where the water is distributed and channelled to the individual gardens (Eldblom L., 1968, p. 114). It is there where the main transactions (i.e. sale of land and water shares...) and exchange take place, where disputes and controversies are raised or solved (Ibid, p. 116). This area may be seen as the main interface ground between the male inhabitants of the separate quarters.

The comparison of the simulated movements given by the choice and the random journeys from the outside, shows a strong interface between the two types of movements (correlation coefficient: 0.799, with journey quantities square rooted). This interface, as expected, takes place at the market square and at the mosques, with the most selected space for both movements running across the market and linking the two quarters together. Men, both inhabitants and strangers, would most probably meet at this area of the town.

CASE TWO: GHARDAIA

	G1	G2	G3
NBER OF SPACES	320	307	308
MEAN CN	2.782	2.710	2.747
MAX. CN	13.000	12.000	12.000
MEAN RRA	1.571	1.764	1.435
MAX. RRA	2.260	2.719	2.124
MIN. RRA	1.129	1.230	0.884
ST. DEV. (RRA)	0.227	0.301	0.242
1:RA/CN	0.460	0.420	0.520
R INTEL.	-0.114	-0.158	-0.058
1:RA/RCH	0.470	0.500	0.520
R. PRED.	-0.160	-0.133	-0.113
CN/CH	0.580	0.550	0.690

TABLE 4.6: GHARDAIA, MEASURES FOR THE THREE VERSIONS

Table 4.6 sets up the measures for the systems of Ghardaia analysed according to the three different versions of representation. G1 refers to the system with the peripheral streets inside the town walls; G2 refers to the system without these spaces, and G3 refers to the system with the gatelines connected to the outside seen as a single entity. The results are:

- The maximum connectivity remains constant for the three versions and is about average. The fact that the mean and the maximum connectivity do not vary considerably when the peripheral spaces are removed suggests that the connectivity of the system is not invested in the peripheral streets.

- In all the versions of analysis, the level of integration is well below average, but the removal of the connections to the peripheral streets has resulted in a loss in the integration of the system through these lines. The connections of the town to the outside has resulted in a slight improvement in the level of integration. The mean integration is now 1.475 compared to 1.571 in G1. The depth of the system (*) measured from the gatelines takes a value of 5.203 compared to 5.227. This means that the integration of the system from the edge is less affected by the removal of the peripheral lines than the internal integration, and suggests that the first idea concerning the relationship between the peripheral spaces and the control of the strangers is not obvious.

- The intelligibility of G1 and G2 is far below the value predicted by the synoptic studies of the 75 systems for systems of similar size. It is about average in G3. In other words, the system of Ghardaia appears to be more intelligible from the outside.

* Depth from the outside is defined as the minimum number of spaces (in terms of spatial transition) which must be crossed to reach a space from the nearest entrance point into the settlement. The mean depth from the outside gives the average distance in terms of axial steps, for all spaces in the system from the outside. For detailed information, see Hillier and Hanson, 1984, p. 106.

- In all cases, the global predictability is below average, and improves, although only weakly, when the system is looked at without the peripheral spaces (G2) and when it is connected to the outside (G3).

- The local predictability of the system is also low in all the versions, weakening to 0.55 with the removal of the peripheral spaces, and improving to 0.69 when the system is connected to the outside.

Ghardaia and its phases of expansion

Two stages of expansion prior to the present town are known in the process of development of Ghardaia (Donnadieu & Didillon, 1977, p.50). The first nucleus started to grow around the main mosque on the top of the hill (Ibid, p. 50). The initial town, and the second stage town, will be referred to as Ghardaia 1 and Ghardaia 2 respectively; Ghardaia 3 will refer to the present town as in G1.

	GHARDAIA 1	GHARDAIA 2	GHARDAIA 3 (G1)
NBER OF SPACES	63	171	320
MEAN CN	2.50	2.50	2.80
MAX. CN	5.00	6.00	13.00
MEAN RRA	1.51	1.76	1.57
MAX. RRA	1.79	2.85	2.26
MIN. RRA	1.18	1.22	1.13
ST. DEV.	0.15	0.33	0.23
1:RA/CN	0.52	0.48	0.46
REL.INTEL.	-0.21	-0.16	-0.11
1:RA/RCH	0.65	0.65	0.47
R. PRED.	-0.13	-0.04	-0.16
CN:CH	0.62	0.70	0.58

TABLE 4.7: GHARDAIA, MEASURES FOR THE THREE PHASES OF EXPANSION.

The results show that:

- the mean integration remains consistently low as the system grows bigger, and is much lower than the average for the 75 urban areas (0.934), but varies considerably from one stage to another.

- the mean connectivity remains also consistently low and well below average, though with some differences between the first two phases and the present system.

- the maximum connectivity increased dramatically when the system has increased in size, especially from the second to the third phase of expansion.

- the intelligibility is low at all phases compared to the values predicted for systems of the same size by the studies of the 75 urban systems, and improves but only weakly as the system becomes larger.

- the predictability given by the integration is poor in the small system (-0.195), and remains so in the larger ones, although there is a marked improvement in the second stage of growth.

- In Ghardaia 1, the integration core is confined to the periphery of the original settlement, penetrating only in one place (see fig. 4.13). It forms a cross-like structure and links directly the mosque to the outside. The three best lines in terms of integration intersect at the mosque and incorporate the spaces that are adjacent to it. The most segregated lines tend, on the other hand, to form as well a relatively continuous structure mainly located on the northern edge of the small settlement. Little information exists concerning the location of the market during this phase.

In Ghardaia 2, the integration core (see fig. 4.14) takes the shape of a crescent linearly expanding east-west across the settlement and following the southern previous town boundaries. This structure includes both the mosque and the small market square, and links but not strongly, the inner parts to the outside. The mosque becomes less spatially integrated, but the market is now the second best integrator. The comparison of the integration core in both, Ghardaia 1 and Ghardaia 2 shows no strong shift in the location of the core. It suggests that the system grows by adding more elements to the old structure rather than by

FIG. 4.13 : GHARDAIA, INTEGRATION CORE (GHARDAIA1)

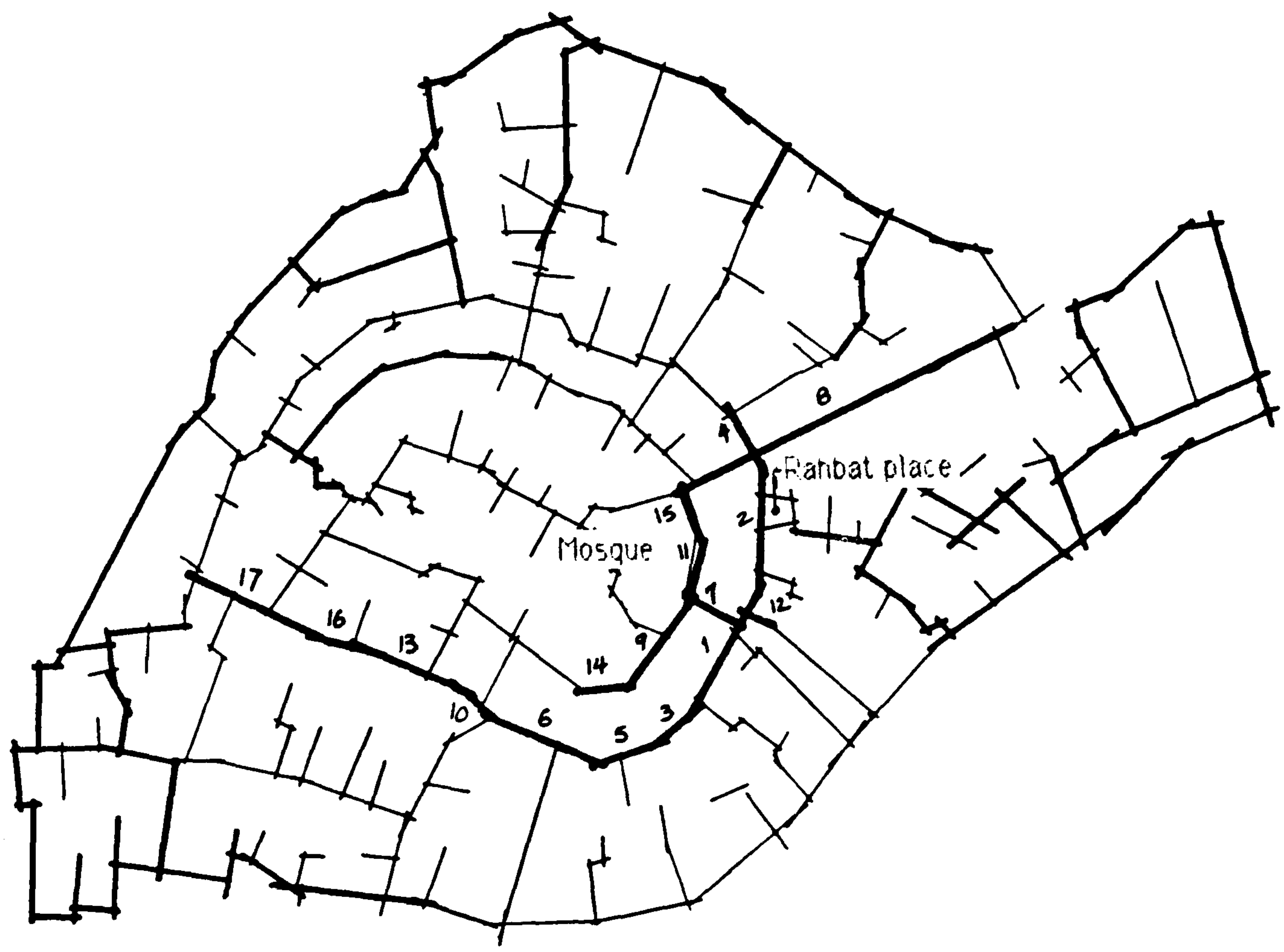

FIG. 4.14 : GHARDAIA, INTEGRATION CORE (GHARDAIA2)

INTEGRATION CORE

50% SEGREGATED SPACES

restructuring the whole system. Yet, a clear change has taken place in the internal structure of the core; for instance, the mosque is no longer a strong spatial element and the linkage to the outside is maintained, though it is much weaker. At this stage, the market was an unimportant element in the Saharan trading network. When the town develops again into a more self-contained structure, it adds, it seems, more elements and more order without again restructuring the older parts. The segregated lines on the other hand, clearly form two clusters of spaces, developing on the periphery of the system and around the integration core.

Some preliminary conclusions can be drawn from this analysis; that is as the system grew larger, it has consistently maintained some spatial properties low. Despite important variations in the levels of integration, these remain very low, and so does the mean connectivity. The intelligibility and global predictibility are also kept low through the growth process.

The second result is that the system, as it grows larger, retains the same level of the overall connectivity, but it considerably increases the maximum values which vary from 5 to 6 to 13. This is possible only if the system, when growing larger, it discriminated few streets and town features from the rest of the system by increasing their connections. These town elements are in fact the market, the commercial streets as could be seen from the axial map in figure 4.2.

THE PATTERN OF INTEGRATION IN GHARDAIA AS A WHOLE (G1):

The spatial analysis of Ghardaia showed striking properties regarding the structure of the integration core and the distribution of the most segregated spaces. The best integrator is located close to the southern edge of the settlement and traverses the market square (see fig. 4.15). The second best integrator intersects with the first at the market square. The third and the fourth best lines in terms of integration form a linear sequence pointing to the north-eastern direction where the main mosque is located, and linking to the old core. The sixth and the nineth directly link the market square to the outside. The map shows that the market square and the streets that lead to it integrate even though they are on the edge of the town. In fact, all of the thirty-two most integrated spaces are located on the southern part of the settlement. They form a continuous structure that links three of the town. gateways to specific areas of the town. Figure 4.15 shows two distinct area that are almost diametrically opposed to each other in the town fabric as a whole.

The segregation map constituted by the 25% of the least integrated spaces shows a well defined segregated zone. These spaces are almost all located on the northern part of the town, despite the fact that many of the town gateways are located on that side. These spaces include one dominant continuous structure, which takes

FIG. 4.15 : GHARDAIA, INTEGRATION CORE (G1)

INTEGRATION CORE
25% SEGREGATED SPACES
50% SEGREGATED SPACES

the shape of a crescent expanding from the northern periphery towards the geographical centre of the town. Many of the spaces that surround the main mosque form part of the most segregated spaces. A higher percentage (50%) of the most segregated spaces strongly confirms the picture already outlined above; the division into two zones is more firmly established (see fig. 4.15). This phenomenon did not occur in the passage from the first to the second stage, although the town has as well doubled in size.

This analysis has shown one dominant characteristic: the location of the integration structure in specific region of the town, leaving therefore a large part not easily accessible. This particular location suggests a potentiality of the spatial structure to accommodate two distinctly separated zones at least in terms of accessibility.

THE PATTERN OF INTEGRATION OF GHARDAIA WITHOUT THE PERIPHERAL SPACES (G2):

The two-sidedness and the non-covering core in the global organisation of this town appears to be a distinctive property. In order to find out more about this point, further analysis is required to investigate the real nature of the integration core. This is aimed to see whether this overall distribution of the most integrated spaces is resulting from the effect of the peripheral streets of the walled city. The question originating from the above analysis is that there may be a relationship between these outer streets and the peripheral and non-covering nature of the integration core. In other words, the existence of the fortification walls and the resulting outer streets may have influenced the peripheral and the non-covering structure of the core. In this exercise, the linkages to the outer spaces that are constituted by the town walls and the peripheral buildings, are then ignored in the input data (lines numbered from 308 to 320 in the axial map, fig. 4.2).

The mapping of the most integrated spaces resulting from the analysis of this revised version of the map shows a clear shift in the internal structure of the core (see fig. 4.16). The best line in terms of integration moves from the market square to the area on the original boundary of the first phase of the town development (see Phases of Development in fig. 2.15). A small mosque lies on it which was according to Donnadieu and Didillon, reserved for the Ibadhite of Wargla during their visits to Ghardaia (Donnadieu and Didillon, 1977, p. 50). This historical evidence makes sense regarding the distribution of the public facilities in relation to the outside users. In fact, this mosque was once on the edge of the old settlement which would have facilitated its access to the visitors from Wargla.

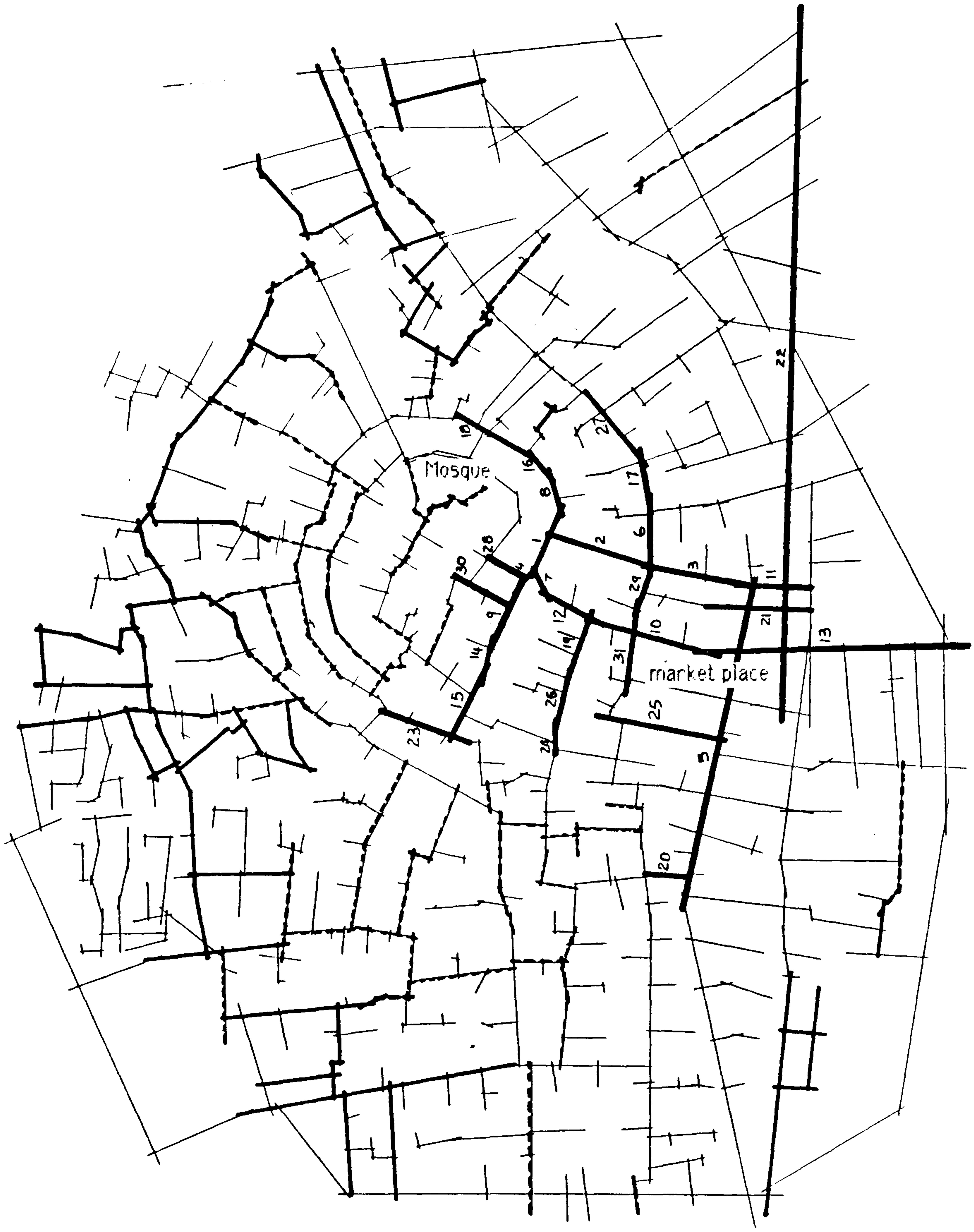

FIG. 4.16 : GHARDAIA, INTEGRATION CORE (G2)

INTEGRATION CORE
25% SEGREGATED SPACES
50% SEGREGATED SPACES

The best three lines in terms of integration form a linear sequence running from the area near the main mosque in the direction of the market and their order is also reversed. These three lines link directly the area adjoining the mosque to the market square. The lines of the market become in this case, less integrated than in the previous analysis (G1). What this result shows is that the dominance of the market square in G1 is to some extent dependent on its links to the periphery. A purely "internal" view of the town showed then a rather different story.

The comparison of figures 4.15 and 4.16 however shows no strong variations with regard to the overall shape and location of the integration core in the town fabric. In both cases, the core remains occupying the southern part of the town. But, the main difference between the two cores resides in the order of the lines, especially those in the vicinity of the market square, which becomes less accessible from the outside: the street that links the market square to the outside forms part of the integration core but is classified 13th in G2, compared to 6th in G1. The integration core has now strongly moved towards the mosque.

The spaces around the mosque become also less segregated in G2 than they are in G1. This suggests that the relatively greater segregation of the spaces that are immediately adjacent to the mosque in G1 is also a result of the links of the settlement to the periphery.

In consequence and despite these variations in the internal structure of the cores, the results regarding the overall pattern of distribution of the most integrated and the most segregated spaces are strikingly similar in both cases: G1 and G2. They form two separate clusters of spaces on either side of the geographical centre of the town, where the town mosque is located. Both the most integrated and segregated spaces tend to constitute a continuous structure, which penetrates close to the geometric centre without however, traversing the town fabric.

In conclusion, the removal of the peripheral spaces has an important effect on the internal structure of the integration core, but the overall shape of the core and its location in the whole fabric remains similar. By removing the effect of the peripheral spaces, a clear shift in the integration structure takes place: the first integrator is no longer directly connected with the market. The core runs more from the mosque to the market than from the market to the mosque and to the outside, as seen in G1.

THE PATTERN OF INTEGRATION IN GHARDAIA WITH GATELINES LINKED TO THE OUTSIDE (G3):

The integration maps shown in figures 4.15 and 4.16, were derived from the analysis of the settlements considered as closed systems; that is the connections of the settlement to the outside are not taken into account, and the degree of integration of spaces in this context, refers to the distancing of spaces from every other space, excluding the outside. In the next analysis, these links to the outside will be added and the effect of these connections on the internal structure of the integration core will be also tested. There are seven gateways; most of which are located in the northern part of the town (see Town map in fig. 2.14). In this exercise, all of the gateways are connected to the outside represented as a single entity.

Figure 4.17 sets out the integration core and the most segregated spaces and shows some remarkable results. These can be summarized as follows:

i- The street that links the outside to the market square becomes the first integrator. This demonstrates that the market is strongly dependent on the connections of the town to the outside. It is the strongest integrator with respect to the outside and therefore might be expected to be mainly oriented towards the strangers' use, and in interfacing them with the inhabitants. This shows also the greater relative segregation of the inside of the town.

ii- There is a strong concentration of the most segregated spaces around the mosque.

iii- The overall shape of the core and its location in the whole system remains similar to G1 and G2. The system exhibits the two-sidedness effect, that is a

FIG. 4.17 : GHARDAIA, INTEGRATION CORE (G3)

INTEGRATION CORE
25% SEGREGATED SPACES
50% SEGREGATED SPACES
gateway

strong concentration of the most integrated spaces on one side of the settlement, with only few lines on the opposite edge (see fig. 4.17). These are in fact the four gatelines that are located on the northern part of the town. This is so, because the outside is now the second best integrating element.

The analysis of radius-3 integration for the small systems and for G1 and G2, indicates that in most cases the radius-3 cores include most of the spaces that constitute radius-n cores (see figures 4.18, 4.18a, 4.18b), and suggests that in the system of Ghardaia, the strong local integrators are also strong global integrators. But, radius-3 cores of Ghardaia as a whole, in both G1 and G2 shifts the core more decisively towards the outside in a similar way to G3.

SPATIAL ANALYSIS OF SIMULATED MOVEMENTS IN GHARDAIA:

The choice structure:

The choice structure in Ghardaia (G1) is graphically presented in figure 4.19 which shows the 17 most crossed spaces (*) in the simulation of movements. This map reveals a relatively continuous structure of spaces with strong choice, linking the market square to the area surrounding the town mosque, and to the outside. The most selected space in the simulated movements

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* This represents 25% of the total choice quantities, i.e. the quarter of all theoretical movements.

FIG. 4.18a: GHARDAIA, RADIUS-3 INTEGRATION CORE
(FOR THE SMALL SYSTEMS).

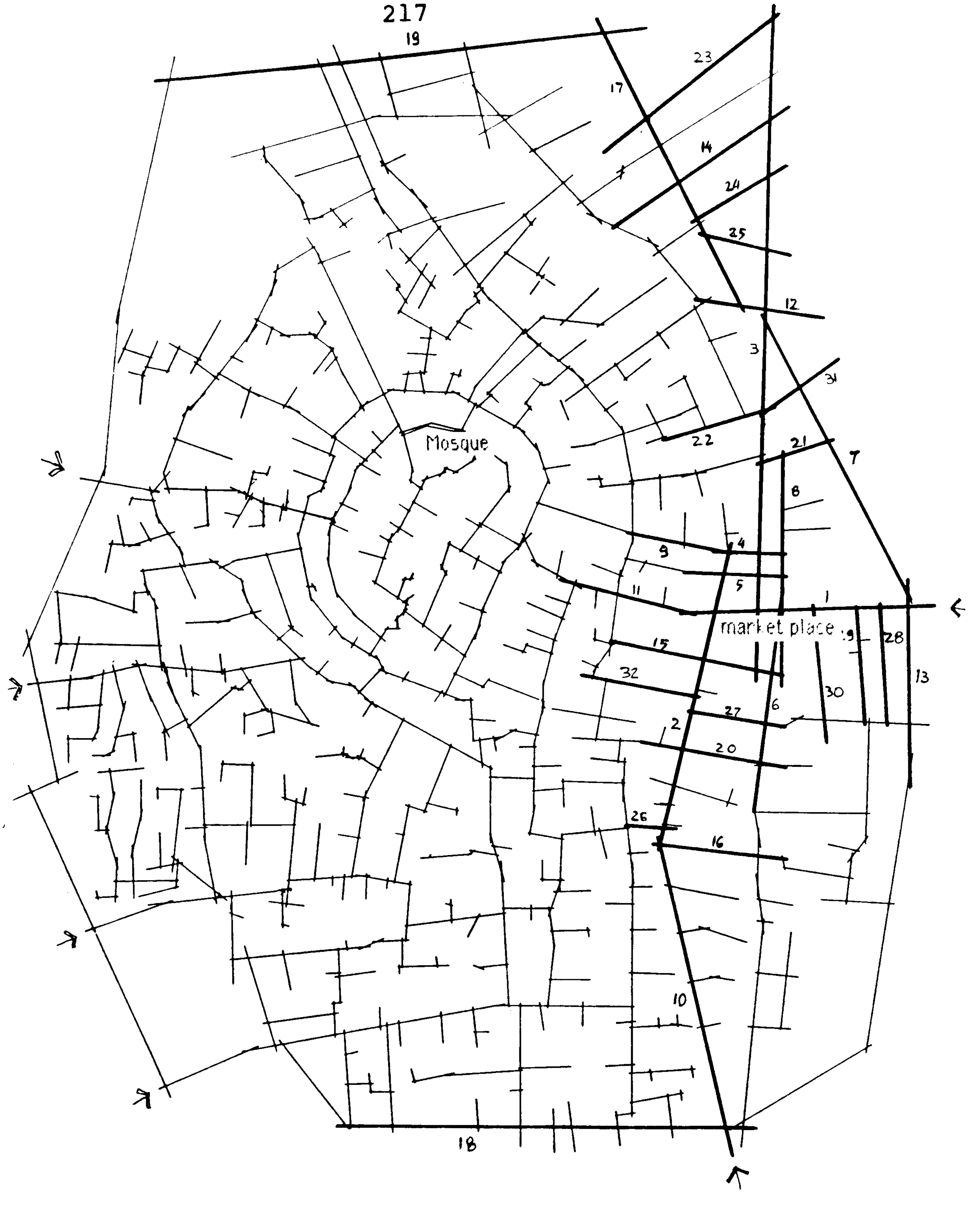

FIG. 4.18 GHARDAIA, RADIUS-3 INTEGRATION CORE G1

→ gateway

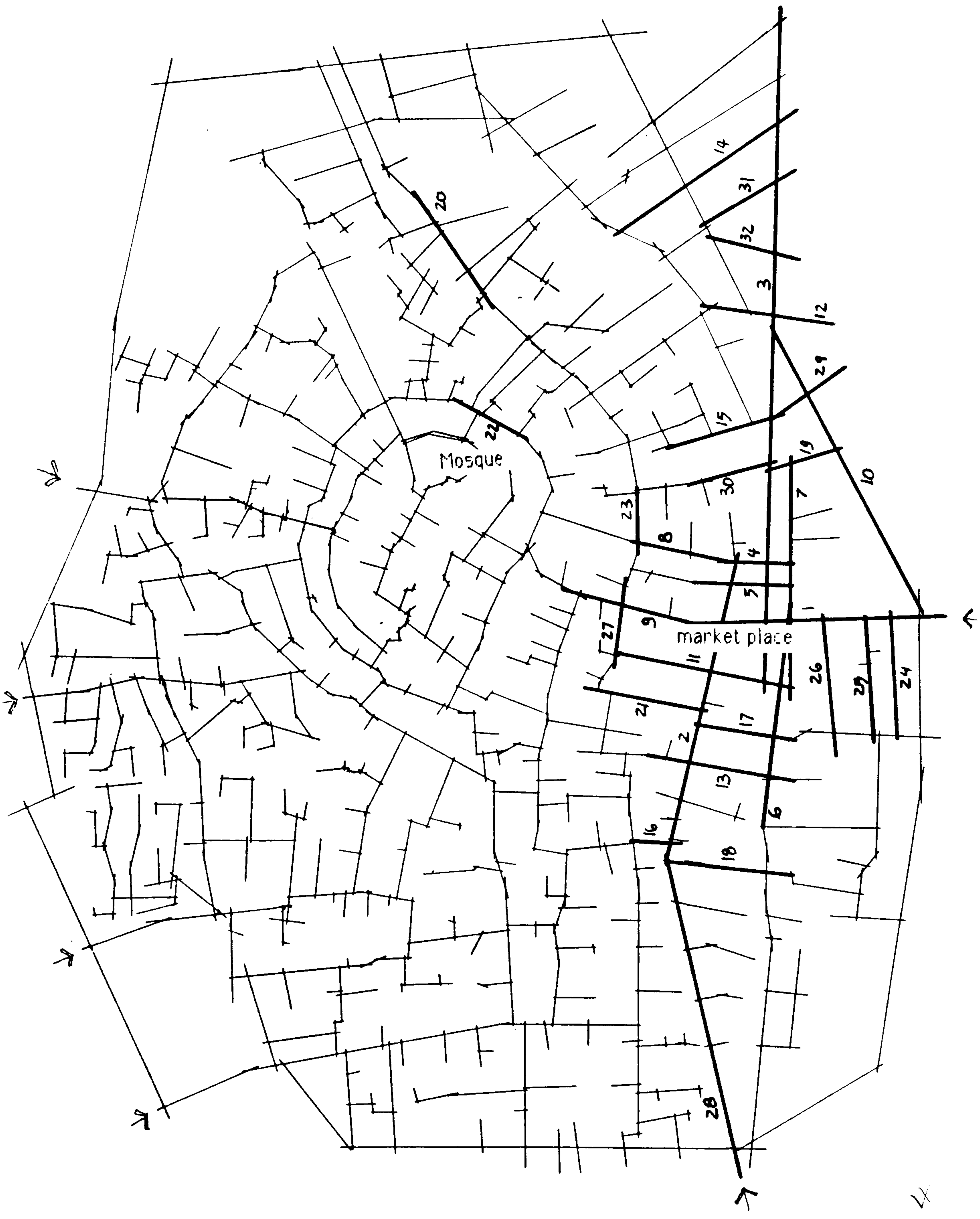

FIG. 4.18b: GHARDAIA, RADIUS-3 INTEGRATION CORE (G2)

→ gateway

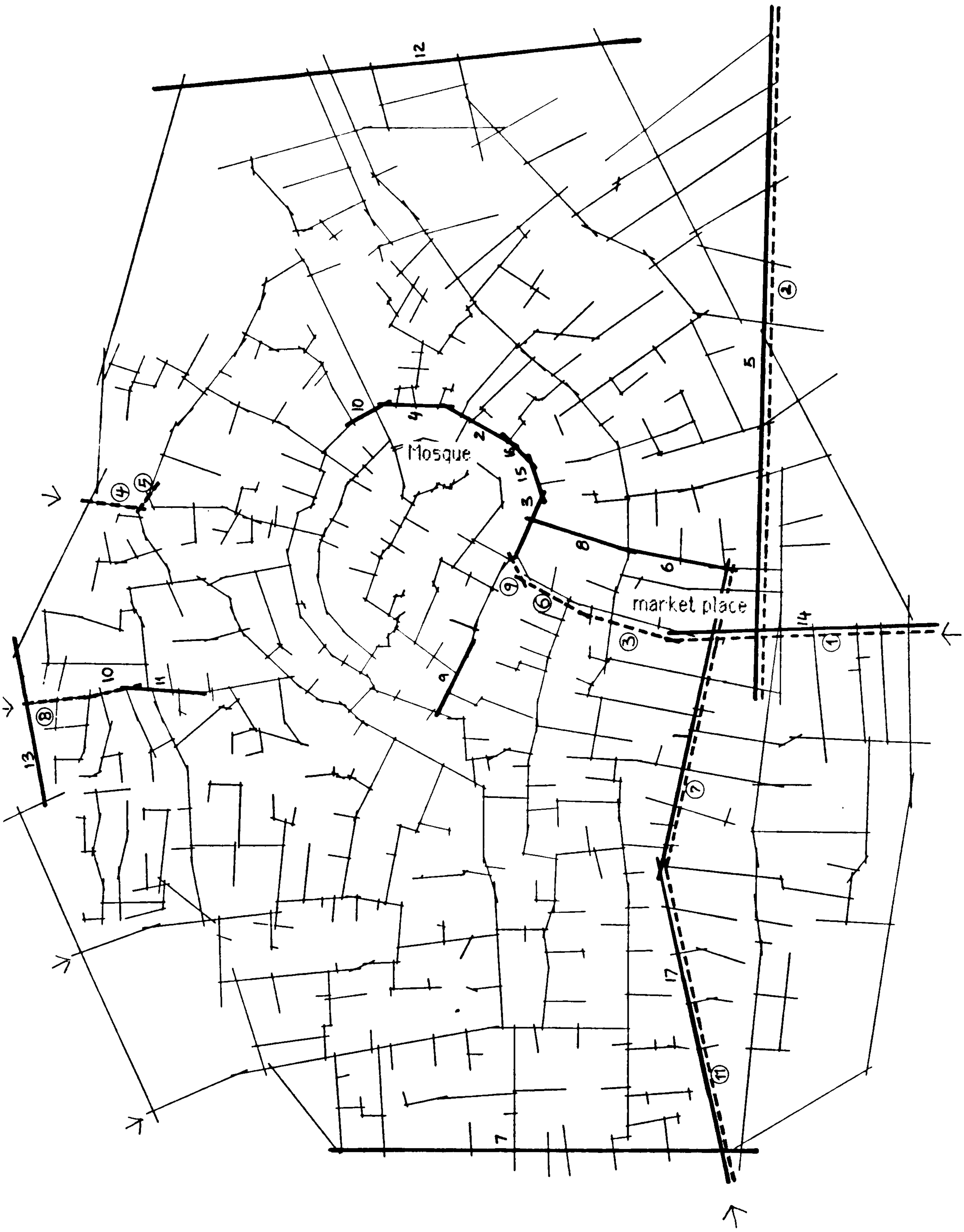

FIG. 4.19 : GHARDAIA, CHOICE STRUCTURE (G1)

CHOICE LINES

RANDOM JOURNEYS FROM OUTSIDE

intersects and includes the market square, and the second most popular passes in the vicinity of the main mosque (only one axial step distant from it). The third most selected space passes near a small mosque, and the fourth includes the original and much smaller market place, which still accommodates three small boutiques and shops. But the town entranceways are not very strong choice lines, and the length of the lines does not seem to be a substantial parameter in determining the "choice route" inside the settlement. The outcome of the analysis shows indeed, that the set of the strong choice lines is made up of very long as well as very short lines.

The analysis of choice has been also carried out on the system without the peripheral streets (G2) and the results are not markedly different from the above analysis (see fig. 4.20). The three most selected lines in the simulated movements, remain the same whether the system is looked at with or without the peripheral spaces.

The results of the simulated movements within the settlement consistently points to the overall conclusions given by the analysis of the integration, in which a large part of the town has been described as not easily accessible with respect to the system as a whole. A clear route has emerged, strongly connecting the market square to the area near the mosque.

But a detailed comparison of internal structure of the

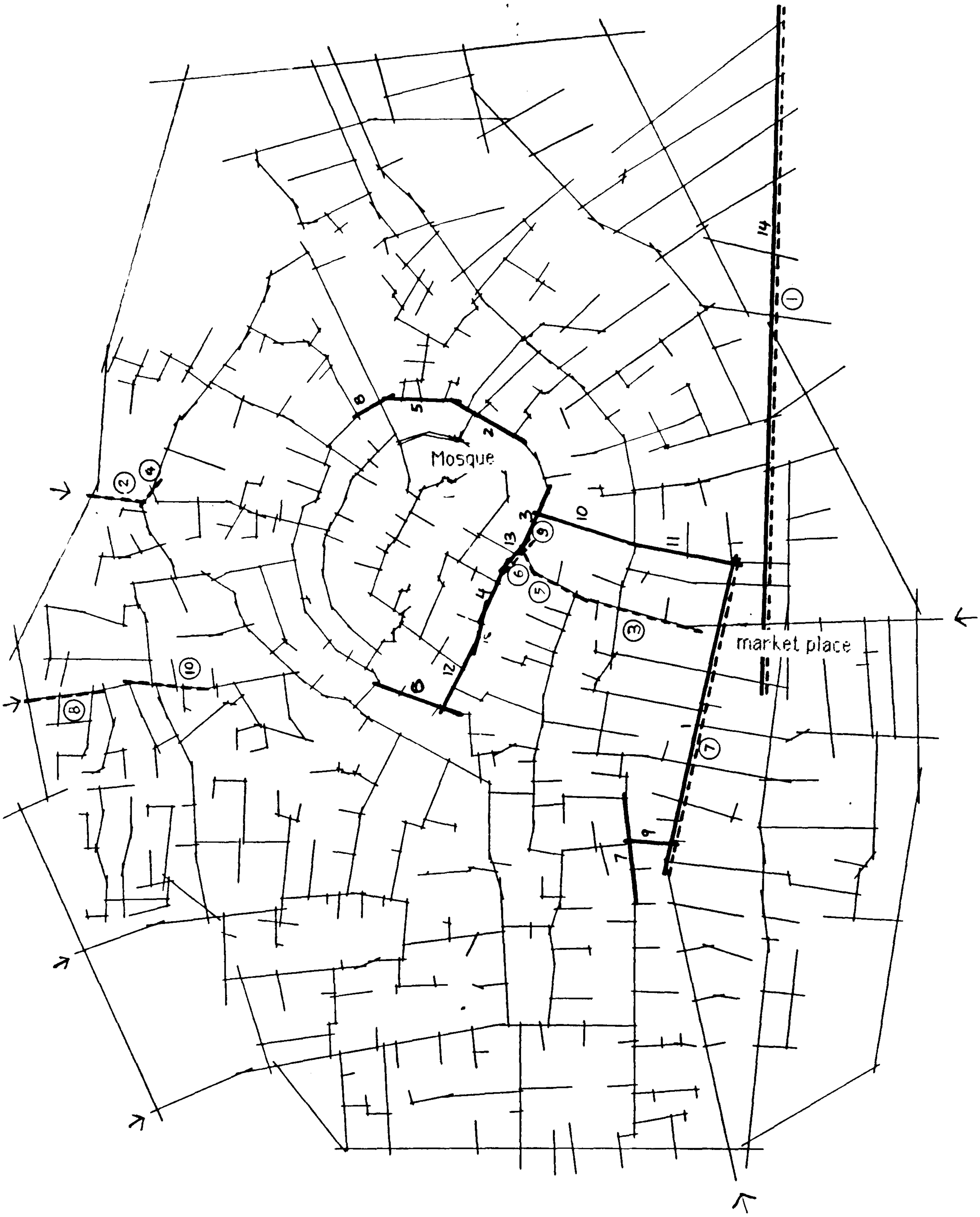

FIG. 4.20 : GHARDAIA, CHOICE STRUCTURE (G2)

CHOICE LINES
RANDOM JOURNEYS FROM OUTSIDE
gateway

the integration core and the choice structure, shows important differences. These reside in the position of the mosque: from the point of view of the integration core, the mosque appeared as strongly segregated, whereas in terms of the choice structure, the mosque has emerged as the second most popular element. This result seems to lend support to the idea that the integration core in Gl may be seen as geared towards the movements of the strangers, and the choice structure representing the popular routes for the inhabitants. Viewed from this point of view, the mosque appears then as a more exclusive building, mainly reserved for the men of the town.

One might speculate that the segregation of the mosque from the integration core and by implication from the movements of strangers may be explained by reference to the history of these people. In Part One, it became clear that the main reason for the past persecution of these communities has been their religious orthodoxy. The fact that the mosque is highly segregated with respect to the outside, but also a strong choice space, could be seen to express its importance in consolidating and preserving the identity of these people, as an inhibitative measure against outsiders. The mosque is required to integrate the inhabitants, but also to be kept away from strangers.

The next section will look at the degree of correlation between the movements generated internally and given by the choice measure, and the movements originating from the outside given by the simulation of random journeys from the outside, in the belief that this may indicate something like the degree of interface between the two types of movements.

The results show that the two movements correlate but not strongly (0.558 with journey quantities square rooted). The distribution of the choice and journey quantities presented by the scattergram in figure 4.21, shows a certain split between the strong spaces. This suggests that there is an interface which only takes place in specific areas of the town.

Figure 4.19 sets out the resulting routes given by the choice and the random journeys from the outside. It shows that the market square emerges as the most important urban element in interfacing the two types of movements. The most selected spaces in the random journeys from the outside constitute a route which strongly connects the market square to the outside, and this may signify that the strangers would be quickly drawn into and out of the system.

When the same exercise is repeated on G2, the correlation becomes then 0.497 (see Scattergram in fig. 4.21a). This is another indication that this town does not seem to depend very strongly on its connections to the periphery for the arrangement of the simulated movements in the town. However, Figure 4.20 shows a weaker version when the peripheral lines are omitted.

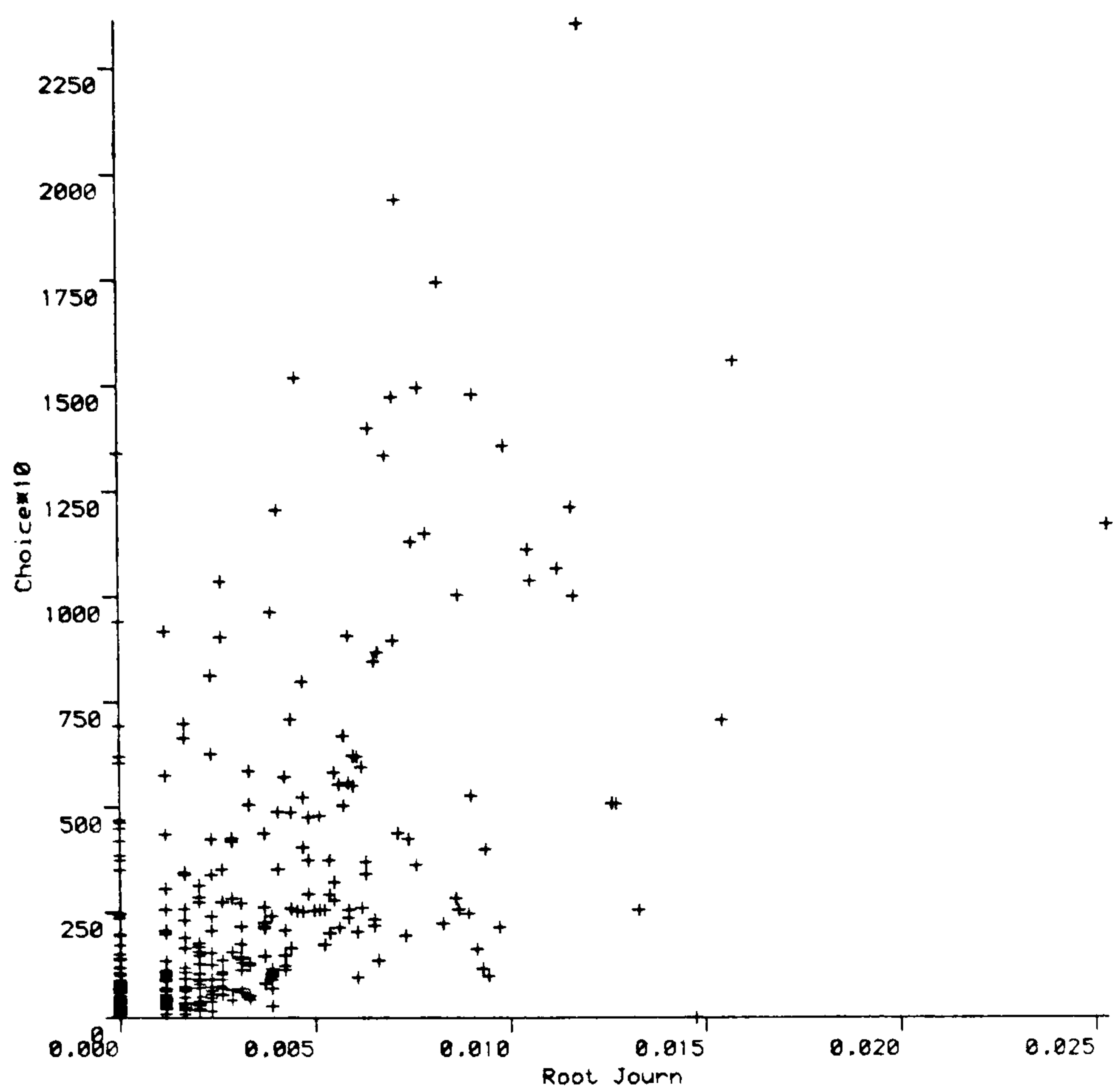

FIG. 4.21 : GRAPHIC DISTRIBUTION OF CORRELATION BETWEEN CHOICE AND JOURNEY QUANTITIES (G1) (CORRELATION = 0.595).

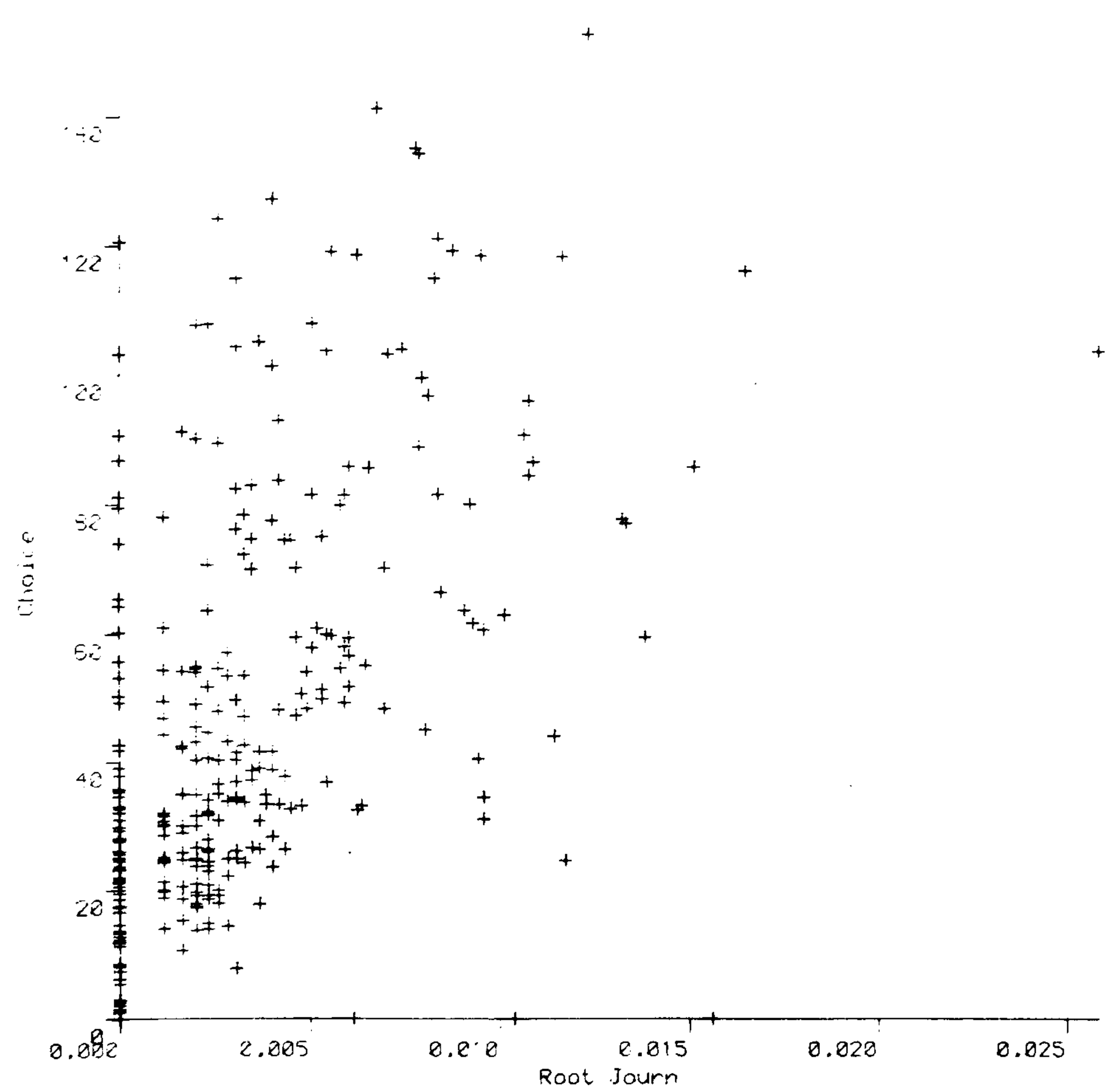

FIG. 4.21a : GRAPHIC DISTRIBUTION OF CORRELATION BETWEEN CHOICE AND JOURNEYS QUANTITIES (G2) (CORRELATION = 0.497).

CASE THREE: BENI ISGUEN

	BI 1	BI 2	BI 3
NBER OF SPACES	264	249	250
MEAN CN	2.930	2.630	2.660
MAX. CN	13.000	7.000	7.000
MEAN RRA	1.285	1.919	1.790
MAX. RRA	1.826	2.958	2.840
MIN. RRA	0.804	1.363	1.290
ST. DEV. (RRA)	0.190	0.340	0.270
1:RA/CN	0.380	0.370	0.400
R. INTEL.	-0.214	-0.230	-0.200
1:RA/RCH	0.530	0.620	0.680
R. PRED.	-0.119	-0.035	+0.025
CN/CH	0.660	0.450	0.450

TABLE 4.8: BENI ISGUEN, MEASURES FOR THE THREE VERSIONS

Table 4.8 summarizes the results of the spatial analysis of the three versions of representation of Beni Isguen, with BI1 referring to the town as a whole; BI2 to the town without the peripheral spaces; and BI3 to the town with the gatelines connected to the outside. . The results show that:

- The mean and the maximum connectivity are about average (compared to the 75 systems) for BI1, but fall dramatically when the peripheral streets are discounted.

- The mean integration is low in BI1 (1.285), and falls substantially when the peripheral streets are removed (1.919), and remains so when the system is linked to the outside as a single space (1.790). The removal of the peripheral spaces has strongly affected the level of integration of the system. In other words, these results suggest that the town depends on the peripheral streets for its integration.

- The intelligibility is very low for the three versions compared to the level of intelligibility expected for systems of the same size. The intelligibility remains more or less constant in the three versions of Beni Isguen.

- The global predictability is below average for BI1 (-0.119), but improves markedly in both cases, when the peripheral lines are removed (BI2, -0.035) and when the system is connected to the outside (BI3, +0.02).

- Table 4.8 shows also a clear loss in the local predictability when the peripheral streets are removed or when the system is connected to the outside. This means that the local predictability of Beni Isguen depends also on the connections of the system to the outside, and that the relatively higher level of local predict bility in BI1 is only created by the peripheral spaces.

Clearly and unlike Ghardaia, the system of Beni Isguen improves markedly the correlation between integration and choice when the peripheral lines are removed or when it is connected to the outside, while at the same time maintaining the same level of intelligibility.

Beni Isguen and its three phases of expansion:

For Beni Isguen, two main phases of expansion prior to the present town (*) are reported in the literature (Donnadieu & Didillon, 1977, p.55; Bousquet G. H., 1982, p.9). These are discernible by the remainings of the previous walls and by the location of the old market squares as well as the old gateways (see fig. 2.18). In the text, the original and the second phase settlement will be referred to as Beni Isguen 1 and Beni Isguen 2; Beni Isguen 3 will refer to the present town, as considered in BI1, that is with the peripheral streets inside the walls.

* The actual expansion was achieved in 1860, the date in which the new fortification walls were built.

	BENI ISGUEN 1	BENI ISGUEN 2	BENI ISGUEN 3 (BI1)
NBER OF SPACES	79	123	264
MEAN CN	2.58	2.73	2.93
MAX. CN	5.00	5.00	13.00
MEAN RRA	1.46	1.61	1.29
MAX. RRA	2.12	2.22	1.83
MIN. RRA	0.92	1.15	0.80
ST. DEV.	0.27	0.24	0.19
1:RA/CN	0.59	0.35	0.38
R.INTEL.	-0.12	-0.32	-0.21
1:RA/RCH	0.74	0.62	0.53
R. PRED.	-0.02	-0.10	-0.16
CN:CH	0.66	0.56	0.66

TABLE 4.9: BENI ISGUEN, MEASURES FOR THE THREE PHASES OF EXPANSION.

Table 4.9 summarizes the results of the spatial analysis for the different phases of expansion of Beni Isguen. These are:

- The mean integration does vary but not so strongly, and remains very low as the system increases in size. It becomes markedly more integrating in the third phase.

- The mean connectivity does improve as the system expands, but remains below average.

- The maximum connectivity remains constant in the first two phases but increases substantially in the last phase of expansion. The consideration of the analytic results of BI2 suggests that the increase in the maximum connectivity is not internal but only confined to the peripheral streets, since the removal of these latter results in a dramatic drop in the maximum connectivity of the system (from 13 to 7).

- The intelligibility is below average in all phases and falls as the system grows larger.

- The predict bility given by the integration is about average in the small system, and strongly falls in the larger ones

- The predictability given by the connectivity remains constant as the town grows, but is below average in all systems.

- In Beni Isguen 1, the integration core takes a linear form expanding internally length-wise across the spatial fabric and strongly connecting the mosque to the market place (see fig. 4.22). The first, third and forth line in terms of integration meet at the mosque and the second best line links the market to the mosque. The most segregated spaces tend to form also a continuous structure on the periphery of the original town. As the system grows, it adds to this pattern of integration (see fig. 4.23) and maintains the mosque and the initial market as the best integrators. At this stage as well, the integration structure does not link to the outside, and the most segregated lines still constitute a continuous structure at the periphery of Beni Isguen 2. The remarkable finding is that

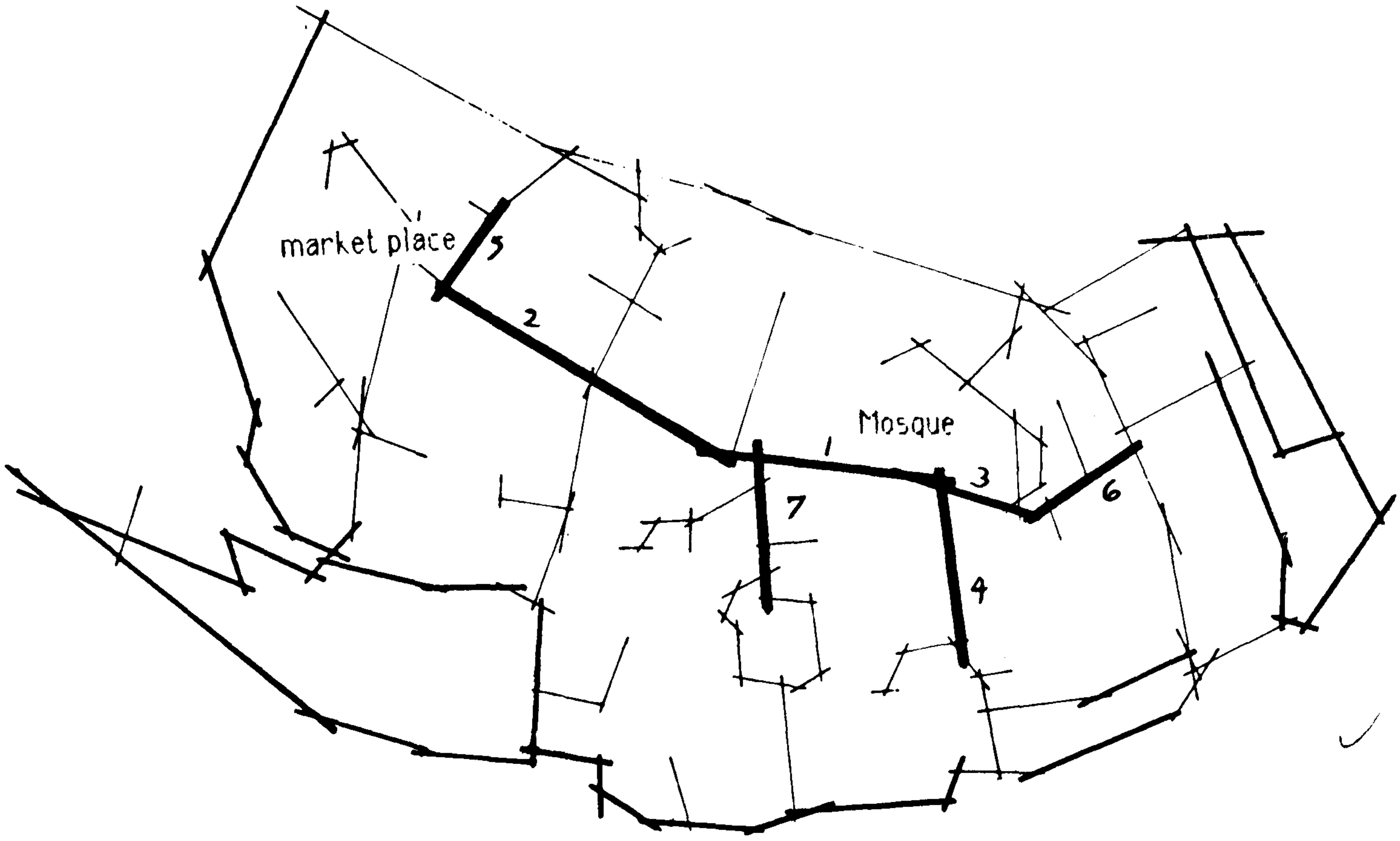

FIG. 4.22: BENI ISGUEN, INTEGRATION CORE (BENI ISGUEN1)

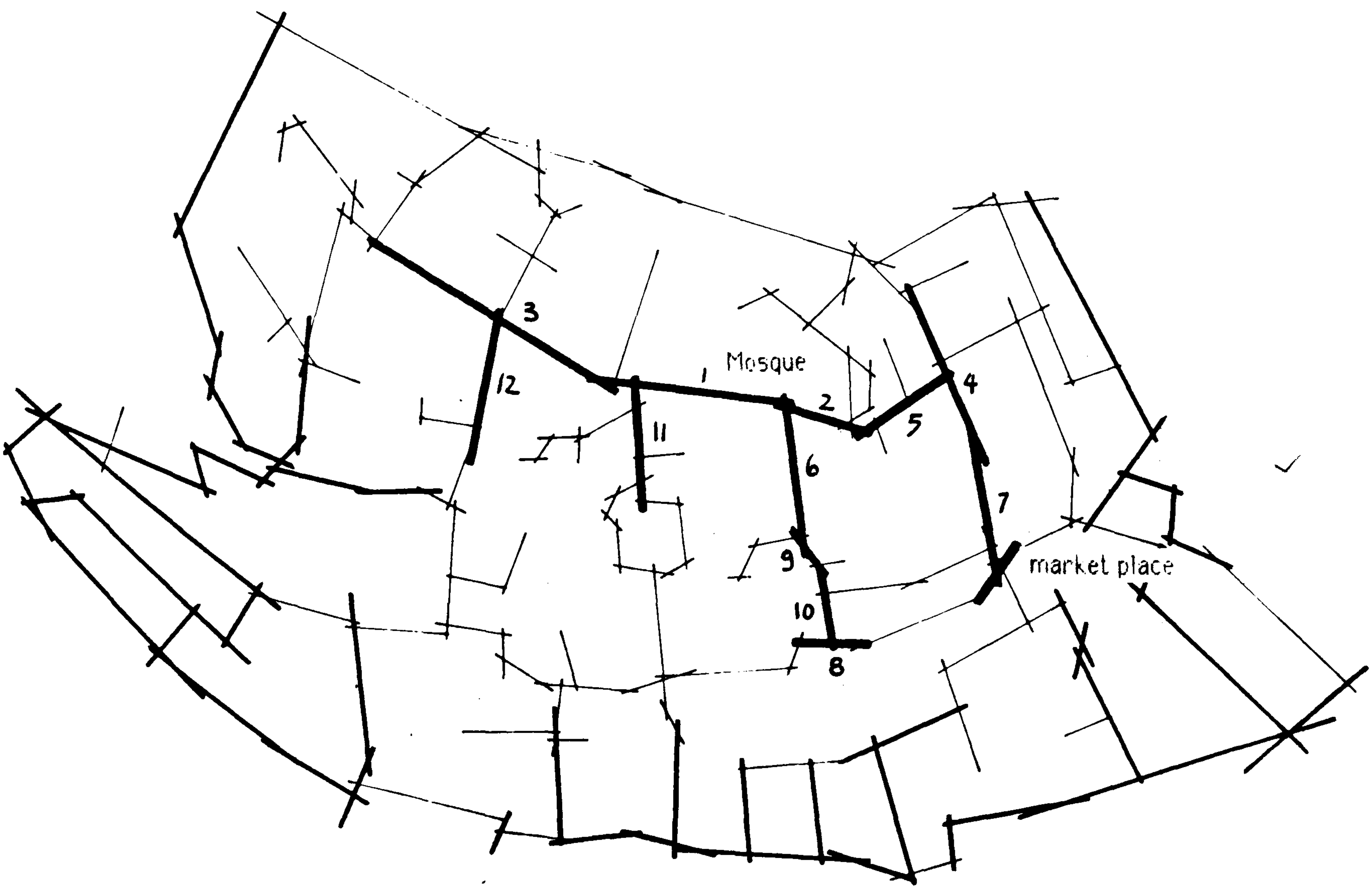

FIG. 4.23: BENI ISGUEN, INTEGRATION CORE (BENI ISGUEN2)

INTEGRATION CORE

50% SEGREGATED SPACES

within this apparent disorder, the two most integrated lines intersect at the mosque, and the third line links the mosque to the initial market place. These are also very strong in terms of choice. When the town grows again (Beni Isguen 3), the integration core becomes more complex as will be seen in the following sections, and excludes the spaces adjoining the mosque.

THE PATTERN OF INTEGRATION IN BENI ISGUEN AS A WHOLE (BI1):

Figure 4.24 shows the 10% most integrated spaces and both the 25% and 50% most segregated elements of the system. This map reveals that the best integrator runs along the peripheral street where there are no public facilities. It is also the longest line in the whole street axial structure. The second and the third join to the first integrator and remain as well on the edge of the town. The fourth and the sixth lines link the periphery to the inner part of the town. All of the components of the integration core consist of a series of penetrating parallel lines joined together only by means of the open spaces that are constituted by the fortification walls and the peripheral buildings. Most of these lines are at most two axial steps from the outside. Unlike Ghardaia, the integration core in Beni Isguen, passes away from both the market square and the main mosque.

This particular location of the integration core on the

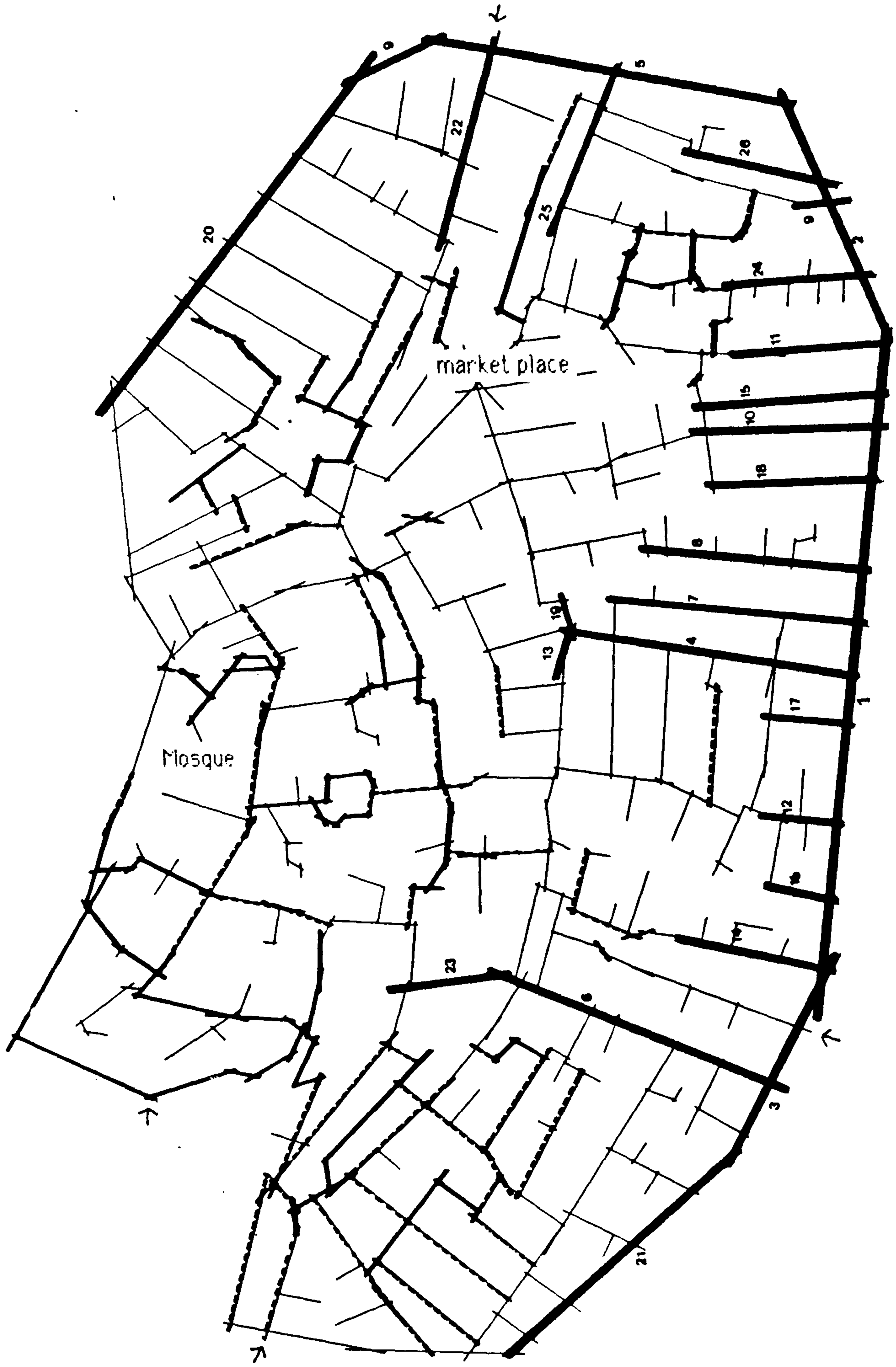

FIG. 4.24: BENI ISGUEN, INTEGRATION STRUCTURE (BI1)

INTEGRATION CORE
25% SEGREGATED SPACES
50% SEGREGATED SPACES

edge leaves by its very nature, a large part of the town highly isolated and not easily accessible. The 25% most segregated lines tend to form clusters which concentrate mainly on the side opposite the area in which the integration core is located. The mapping of the 50% most segregated spaces present a slightly different picture. These tend to form a continuous and more circuitous structure. The spaces around the town mosque form part of the segregated spaces. Thus, the integration core and especially the fact that it passes away from the main activity areas (i.e. the market square) suggests some underlying differences in the way in which the two towns, Ghardaia and Beni Isguen, work.

THE PATTERN OF INTEGRATION OF BENI ISGUEN WITHOUT THE PERIPHERAL SPACES (BI2):

Next, Beni Isguen will be analysed by omitting the connections of the peripheral streets to the adjoining spaces within the settlement. This exercise yields dramatic results. Unlike the peripheral core of BI1 (see figures 4.24 and 4.25), the integration core in BI2, consists of a continuous pattern which develops across the town, and passes through both the old and present market square, linking the periphery, but not the gateways, to the market square. The four best lines in terms of integration run along the old town boundaries as shown in figure 4.25. These lines are on the whole very short and form a distinct structure with respect to the overall shape of the integration core, and to which several other highly integrated lines (indexed 7, 8, 21 and 25 in fig. 4.25) join to make a tree-like pattern. The most segregated spaces, on the other hand, tend to form three distinct clusters located on the periphery of the town. These clusters include a large number of the spaces that connect to the peripheral streets. But the superposition of figures 4.24 and 4.25 shows that the area to the southern periphery remains strongly segregated in both, BI1 and BI2.

This is completely the reverse situation of the analysis conducted on the settlement as it presents itself, that is with the remparts and the peripheral streets forming a ring around the town. The integration core (in BI2) passes as well in the vicinity of the main mosque without however, including it.

With respect to the system of integration, the peripheral streets constituted by the town walls, have a major effect on the distribution of both the highly integrated and segregated spaces on the town fabric. In fact, the structure of the core is similar to Ghardaia's, in one sense, in that it has a non-covering pattern, and is confined to one zone of the town.

SPATIAL ANALYSIS OF INTEGRATION OF BENI ISGUEN WITH GATELINES LINKED TO THE OUTSIDE (BI3):

In the case of Beni Isguen, there are four gateways

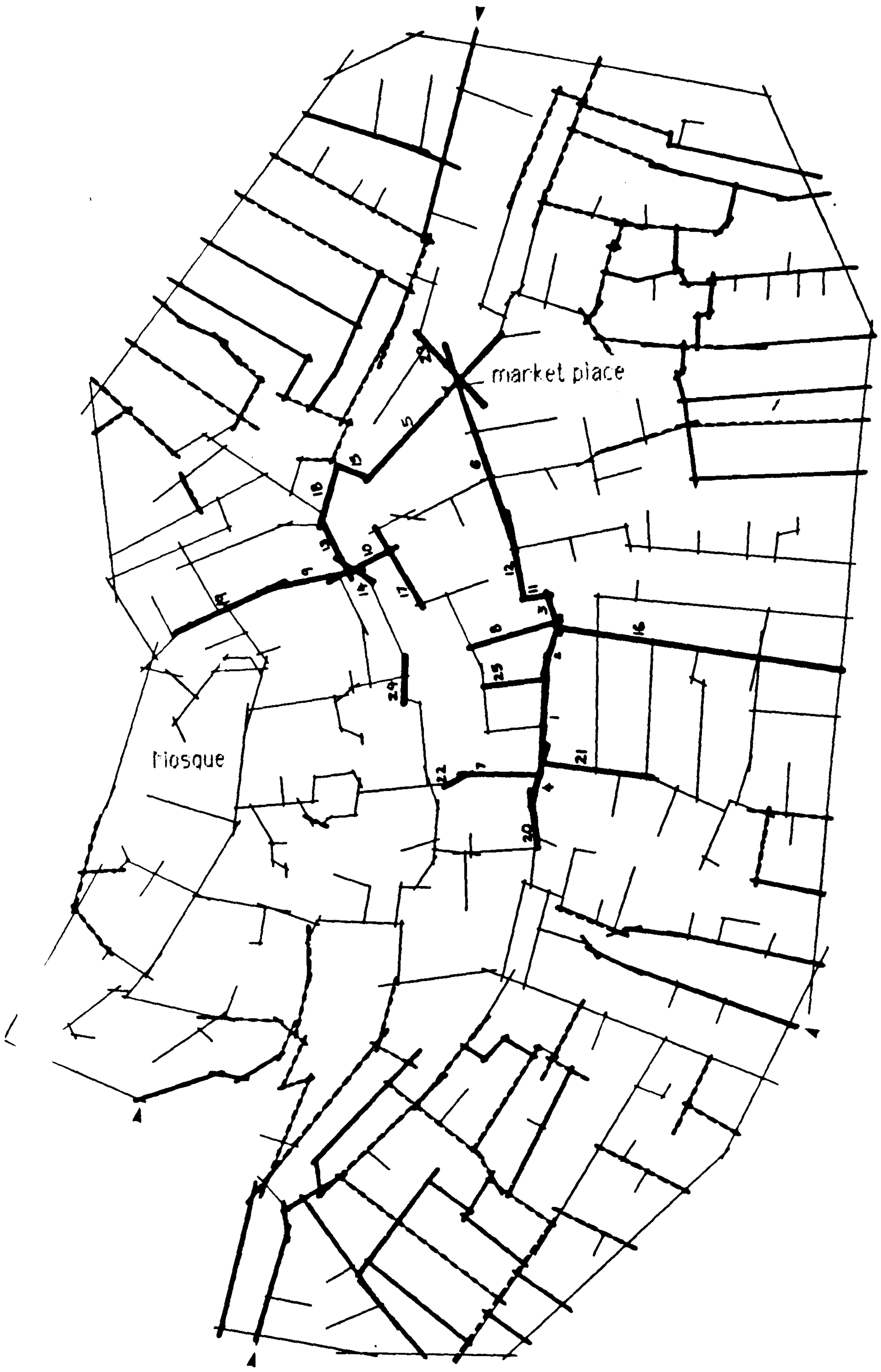

FIG. 4.25 : BENI ISGUEN, INTEGRATION STRUCTURE (B12)

INTEGRATION CORE
25% SEGREGATED SPACES
50% SEGREGATED SPACES

which constitute the only entrance points to the town (see Town Map in fig. 2.17). In this exercise, the outside has been connected to all four gatelines and the resulting patterns of the most integrated and segregated spaces are set out in figure 4.26 which shows that:

i- The market becomes by far the most integrating element: the three best lines in terms of integration all traverse and intersect at the market square. In other words, the market might be seen to be highly oriented towards the strangers' use who have been admitted into the system, though it remains not directly connected to the outside as it is the case in Ghardaia (G3). This difference between the two towns might be explained by the fact that the market in Ghardaia is the most important in the whole valley. It was also an important caravan centre in the trans-saharan commerce. For this reason, its links to the outside are crucial to fulfill this assigned task. For Beni Isguen, the town is more of a spiritual, religious and exclusive centre; its links to the outside are carefully guarded. Access to the strangers is not made obvious, and when admitted into the "interior" of the town, their movements tend to be spatially directed towards the market, the only place in which they do not need any explanation for their presence.

ii- The area in the vicinity of the mosque becomes relatively more segregated with respect to the outside,

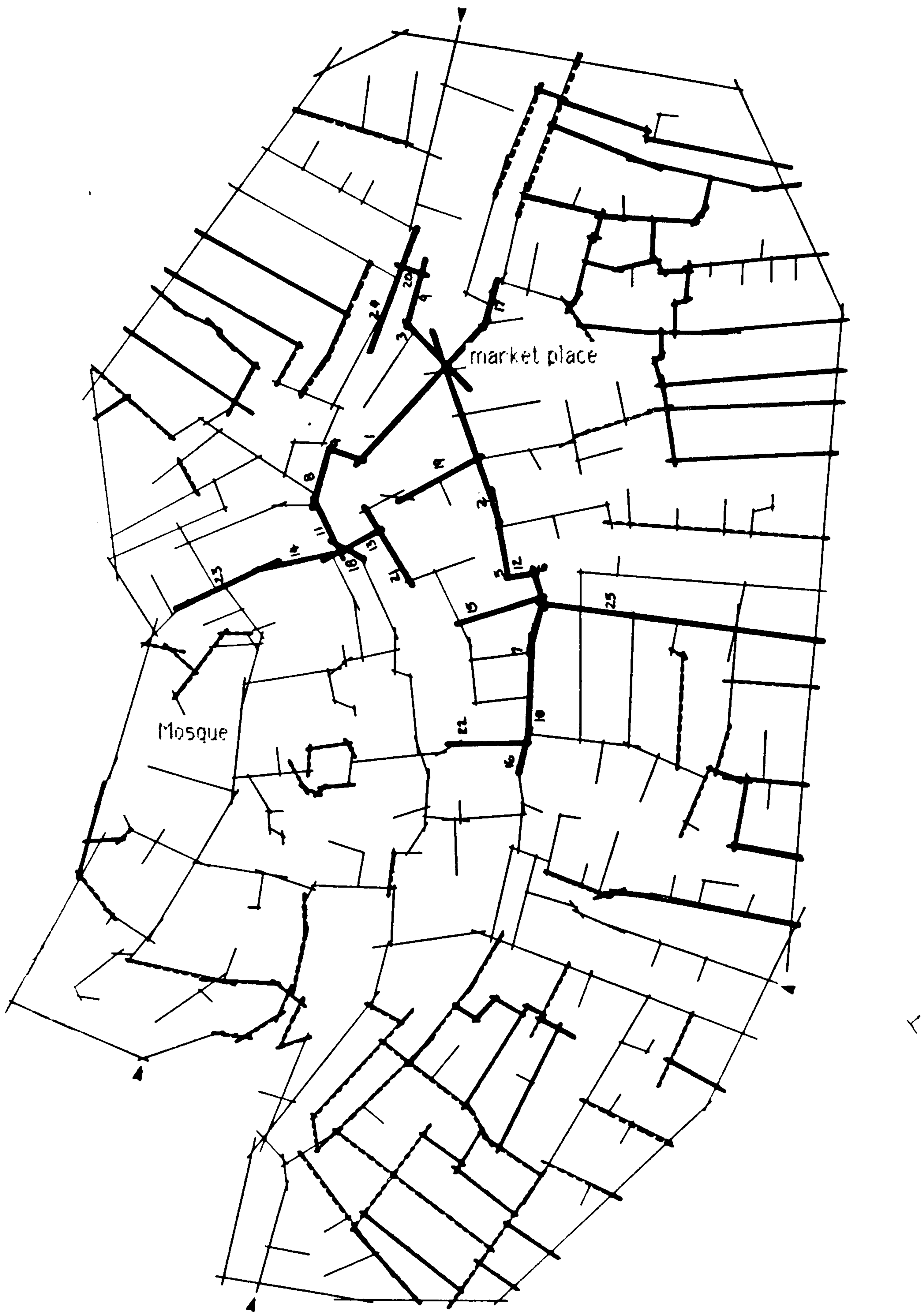

FIG. 4.26 : BENI ISGUEN, INTEGRATION STRUCTURE (BI3)

INTEGRATION CORE
25% SEGREGATED SPACES
50% SEGREGATED SPACES

a similar result to Ghardaia (G3).

iii- The overall shape of the integration core and its geographical position in the whole fabric, remain similar to BI2.

The above analysis suggests that Beni Isguen has in consequence two integration cores: one peripheral and passes away from the town's facilities; the other more internal and includes the area around the market, which has emerged as the main integrator with respect to the outside.

As in Ghardaia, radius-3 integration cores of the small systems of Beni Isguen overlap to a great extent with their radius-n cores (see fig. 4.27). But, radius-3 core of the town as a whole shows a different picture from radius-n integration cores (see figures 4.27a, 4.27b). For BI1 (the town with peripheral spaces, radius-3 core includes many spaces of the integration core (radius-n), and also some of the most segregated spaces. When the peripheral spaces are removed (BI2), radius-3 core hardly overlaps at all with the integration core of BI2. Moreover, it consists of many spaces that are strongly segregated with respect to the whole. This suggests then that Beni Isguen as it grew, seems to have developed such features as spaces that are strongly locally connected in parts of the system, but that are not globally integrating. This seems an important principle in Beni Isguen which appears to

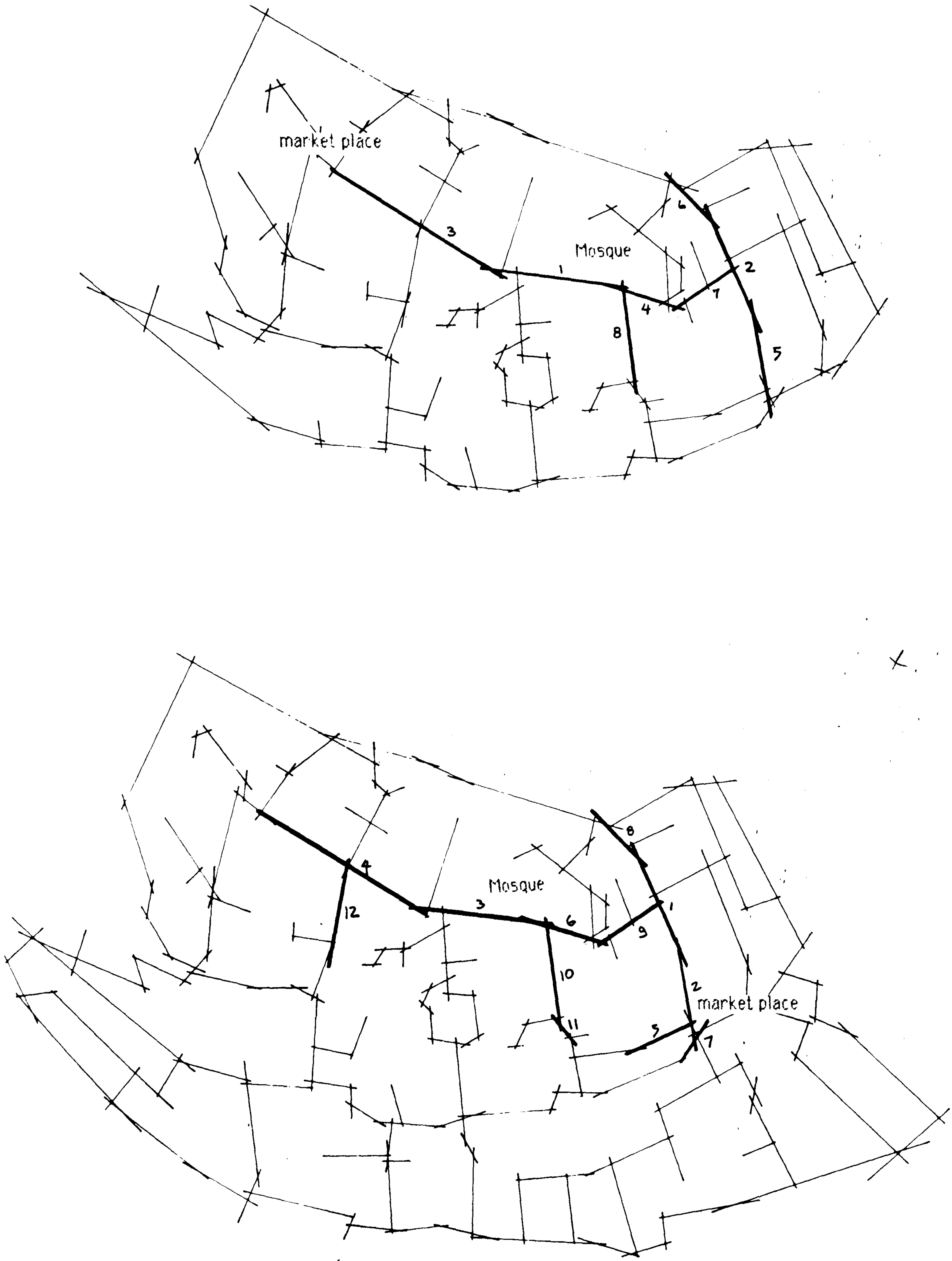

FIG. 4.27: BENI ISGUEN, RADIUS-3 INTEGRATION CORES
(FOR THE SMALL SYSTEMS).

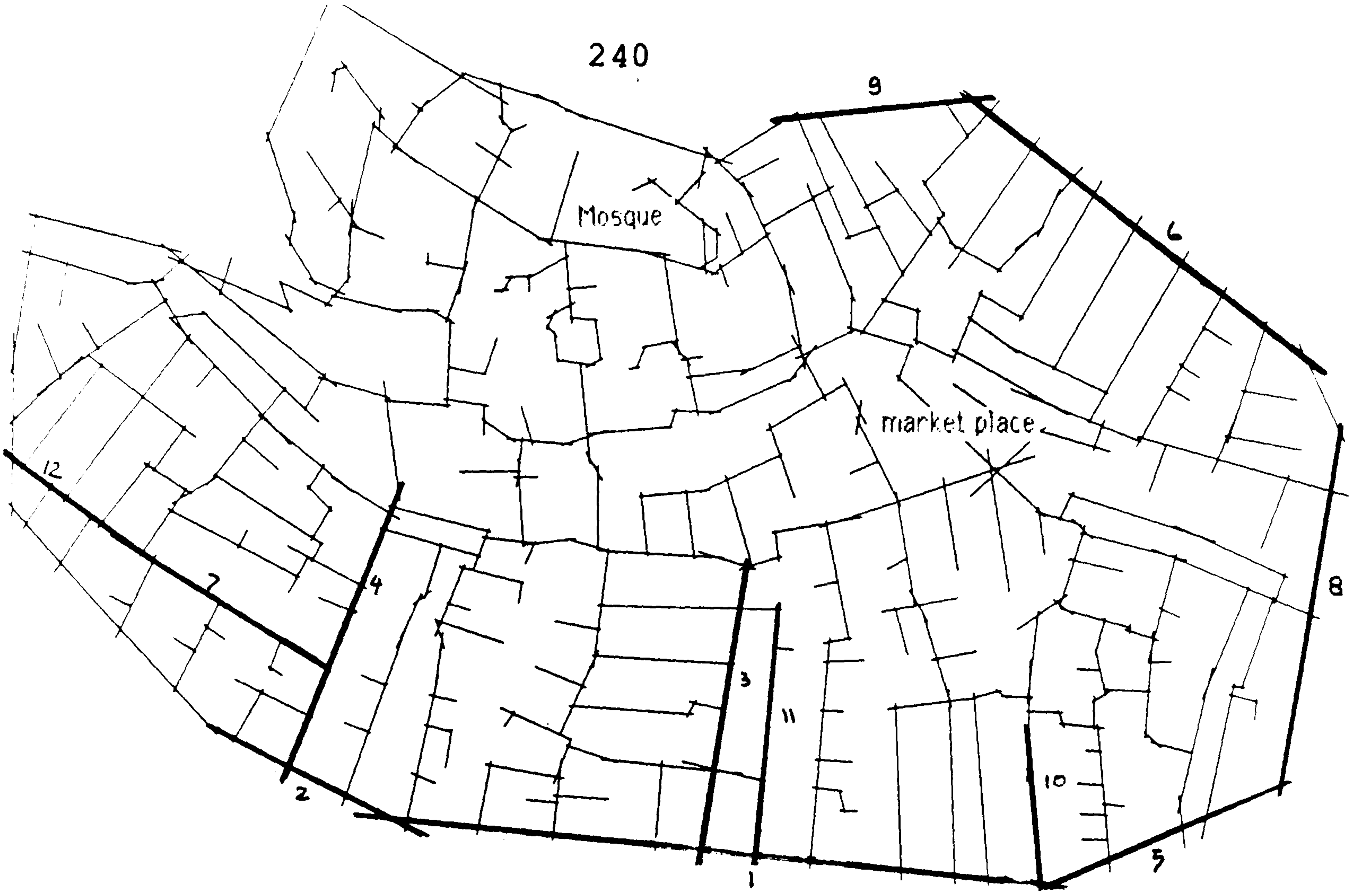

FIG. 4.27a: BENI ISGUEN, RADIUS-3 INTEGRATION CORE (BI1)

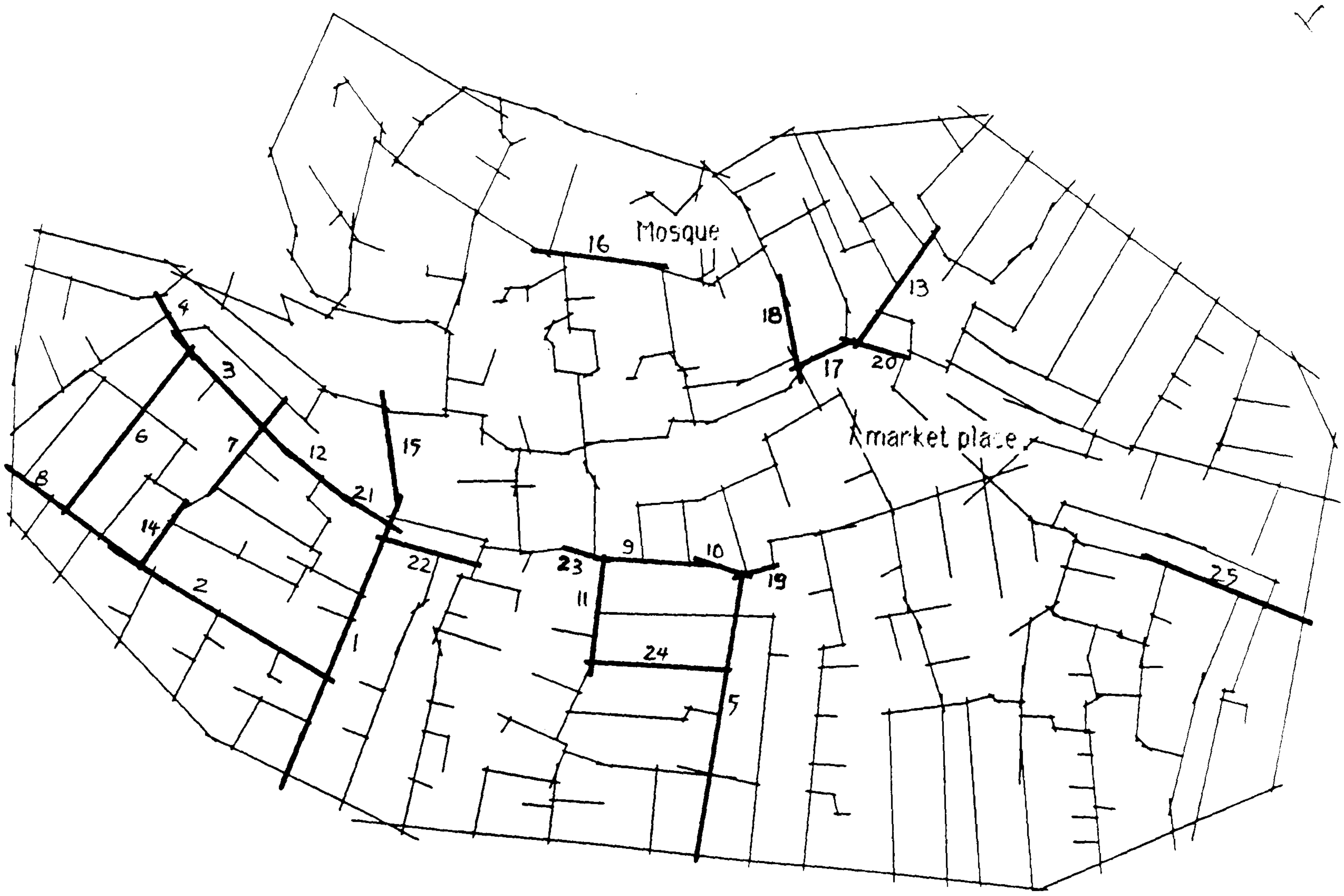

FIG. 4.27b: BENI ISGUEN, RADIUS-3 INTEGRATION CORE (BI2)

develop much more localized structure than Ghardaia.

THE ANALYSIS OF SIMULATED MOVEMENTS IN BENI ISGUEN:

The choice structure:

Figure 4.28 shows the route resulting from the mapping of the strong choice lines in BI1, which consists almost entirely of the streets surrounding the system. In other words, the choice structure does not penetrate the town but only surrounds it, and therefore passes away from the main town facilities. Apart from Line 4 which links the inner areas of the town to the peripheral streets, all of the other strong choice lines remain on the edge, inside the town walls.

When the peripheral streets are discounted, the choice structure consists then of a group of linked spaces in the market area, inside the system. Figure 4.29 reveals that the market square emerges from the simulation as the most popular space. The second most selected space goes from the periphery towards the interior of the town without however, linking to the gatelines. The mosque remains isolated with respect to this route. In other words, the results of the simulation of movements in BI1 and BI2, suggest that the town might depend on the peripheral streets, not on its links to the outside, for structuring the movements inside the system.

The simulation of random journeys originating from the

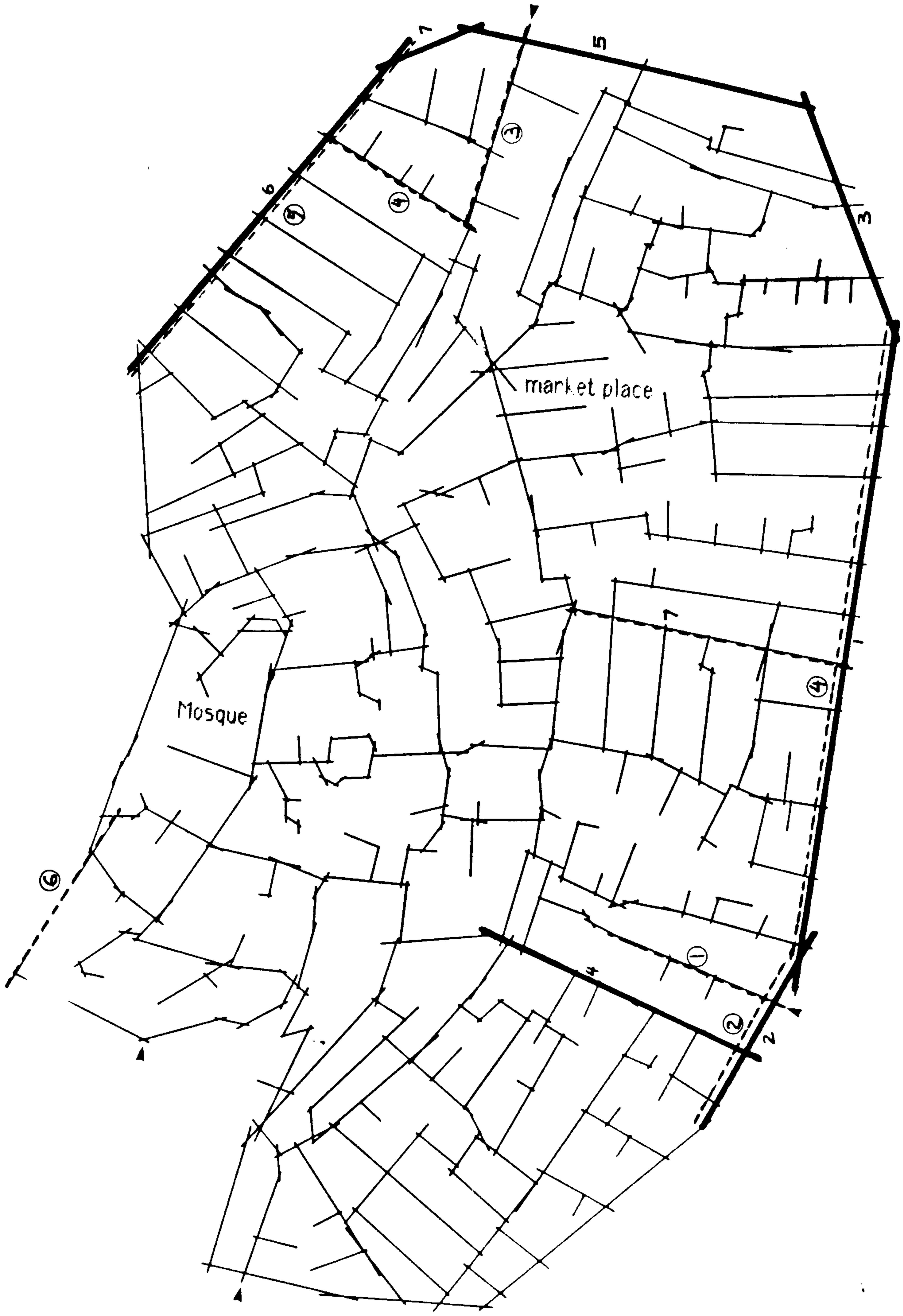

FIG. 4.28 : BENI ISGUEN, CHOICE STRUCTURE (BI1)

CHOICE STRUCTURE
RANDOM JOURNEYS FROM OUTSIDE

FIG. 4.29: BENI ISGUEN, CHOICE STRUCTURE (BI2)

CHOICE STRUCTURE
RANDOM JOURNEYS FROM OUTSIDE

outside on BI1 map of Beni Isguen and its comparison to the choice quantities, shows a significant correlation (0.748), but the graph in figure 4.30 illustrating the distribution of these quantities reveals that the best spaces for the two simulations remain on the edge of the town. On the other hand, when the same exercise is repeated on the system without the peripheral spaces, the correlation between the choice and random journeys from the outside sharply falls to 0.236. The scatter-gram in figure 4.31 shows a clear bifurcation between the best spaces in terms of both choice and random journeys quantities, and figure 4.29 locates these spaces on the town map. The market square does not form part of the random journeys spaces, and is more "internal", in contrast to Ghardaia's which is more important in the Saharan trade. Therefore, the interface of the internal movements and the movements originating from the outside seems also to be dependent very much on the peripheral streets, with the market square clearly kept away from the random journeys from the outside.

The results given by the analysis of the integration structure in the different versions of the town mapping, have shown two types of cores, one peripheral and the other internal but not covering, with the predominance of the market square when the links of the system to the outside are considered. On the other hand, the consideration of the theoretical definitions which associate the integration core with the movements of

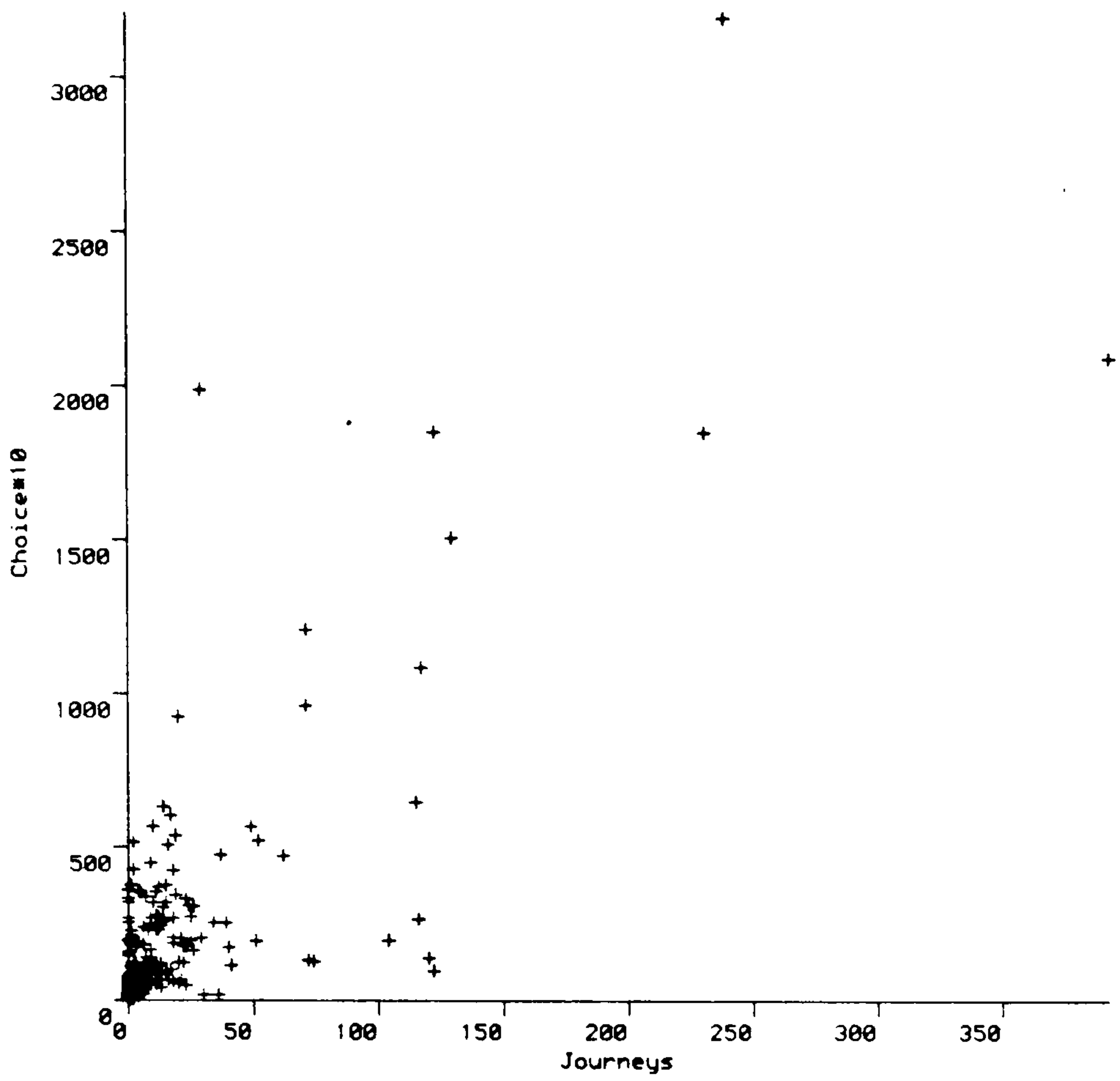

FIG. 4.30 : BENI ISGUEN, GRAPHIC DISTRIBUTION OF CORRELATION BETWEEN CHOICE AND JOURNEY QUANTITIES (BI1) (CORRELATION = 0.748).

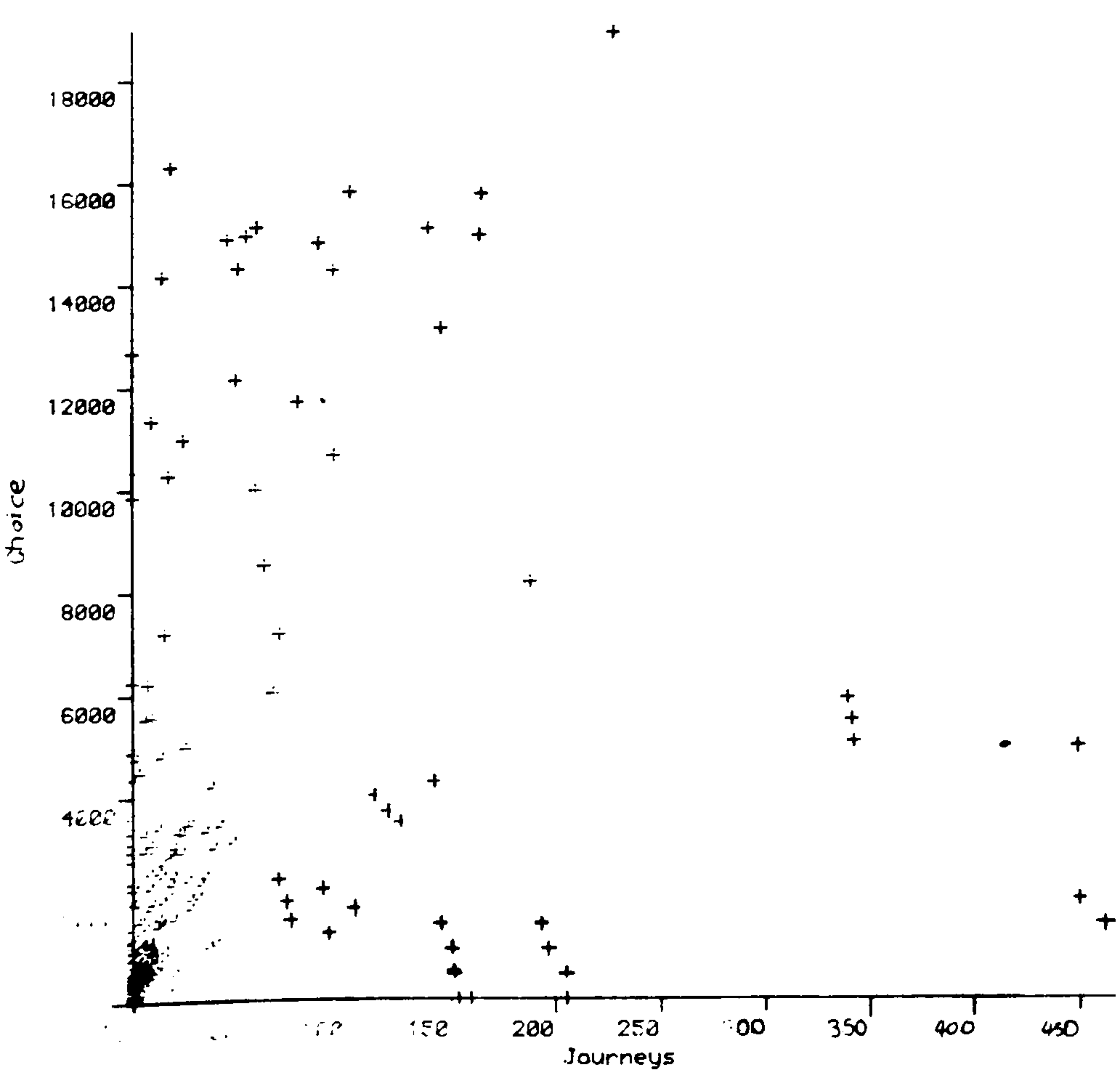

FIG. 4.31 : BENI ISGUEN, GRAPHIC DISTRIBUTION OF CORRELATION BETWEEN CHOICE AND JOURNEY QUANTITIES (BI2) (CORRELATION = 0.236).

strangers and the choice structure with the movements of the inhabitants, and the results given by the simulations of movements, both internal and random from the outside, suggests that for Beni Isguen, there may be two types of interfaces between the two groups:

- The first being more probabilistic and incidental, takes place on the periphery; and the second more deterministic, requiring more knowledge of the system and takes place in the market place. This suggestion is supported by the common practice that when strangers are admitted into the town, they are usually led by a guide to the market place, the only area in which a justification for their presence is not required (*).

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* A stranger, in order to visist Beni Isguen must be "escorted" by a guide; he must get in from specific gateways and at a specific time, or no stranger is allowed after sunset.

CASE FOUR: EL OUED

	ELO 1	ELO 2
NBER OF SPACES	44	45
MEAN CN	3.55	3.57
MAX. CN	9.00	9.00
MEAN RRA	0.85	0.79
MAX. RRA	1.28	1.26
MIN. RRA	0.47	0.41
ST. DEV.(RRA)	0.21	0.20
1:RA/CN	0.73	0.73
R INTEL.	-0.03	-0.03
1:RA/RCH	0.74	0.78
R. PRED.	-0.07	-0.03
CN/CH	0.76	0.66

TABLE 4.10: EL OUED, MEASURES FOR THE TWO VERSIONS

Table 4.10 sets up the measures for the two versions of the analysis of El Oued (ELO1: the town as a closed system; ELO2: the town connected to the outside). It shows that:

- The mean connectivity for the two versions is average (compared to the 75 systems) and does not vary when the system is linked to the outside.

- The maximum connectivity remains also constant in the two versions, and is below average.

- The mean integration in ElO1 is higher than average (0.83), improving to 0.79 when the system is connected to the outside.

- The intelligibility of El Oued is about average in both versions, and does not vary according to whether the system is linked to the outside or not.

- The global predictability of ElO1 is also about average (-0.07), improving slightly in ElO2 (-0.03); while the local predictability is average in ELO1 (0.76), worsening to 0.66 when the connections of the system to the outside are considered.

The results of the two analyses of El Oued show no strong variations in the numerical properties of the urban fabric. In both cases, the system has shown to be highly integrated and intelligible, with a good level of prediction for simulated movements by both the integration and the connectivity.

THE PATTERN OF INTEGRATION IN EL OUED (ELO1):

The mapping of the most integrated spaces presented in figure 4.32, reveals fundamental differences between the integration core of El Oued and the other three cases. The most integrated spaces form a core which occupies the centre of the settlement and takes the shape of a double cross, completely traversing the spatial fabric in several directions. The first and the second line in terms of integration run parallel to each other; and the third, the fourth and the fifth intersect the two former lines in a perpendicular manner, forming therefore an orthogonal grid-like pat-

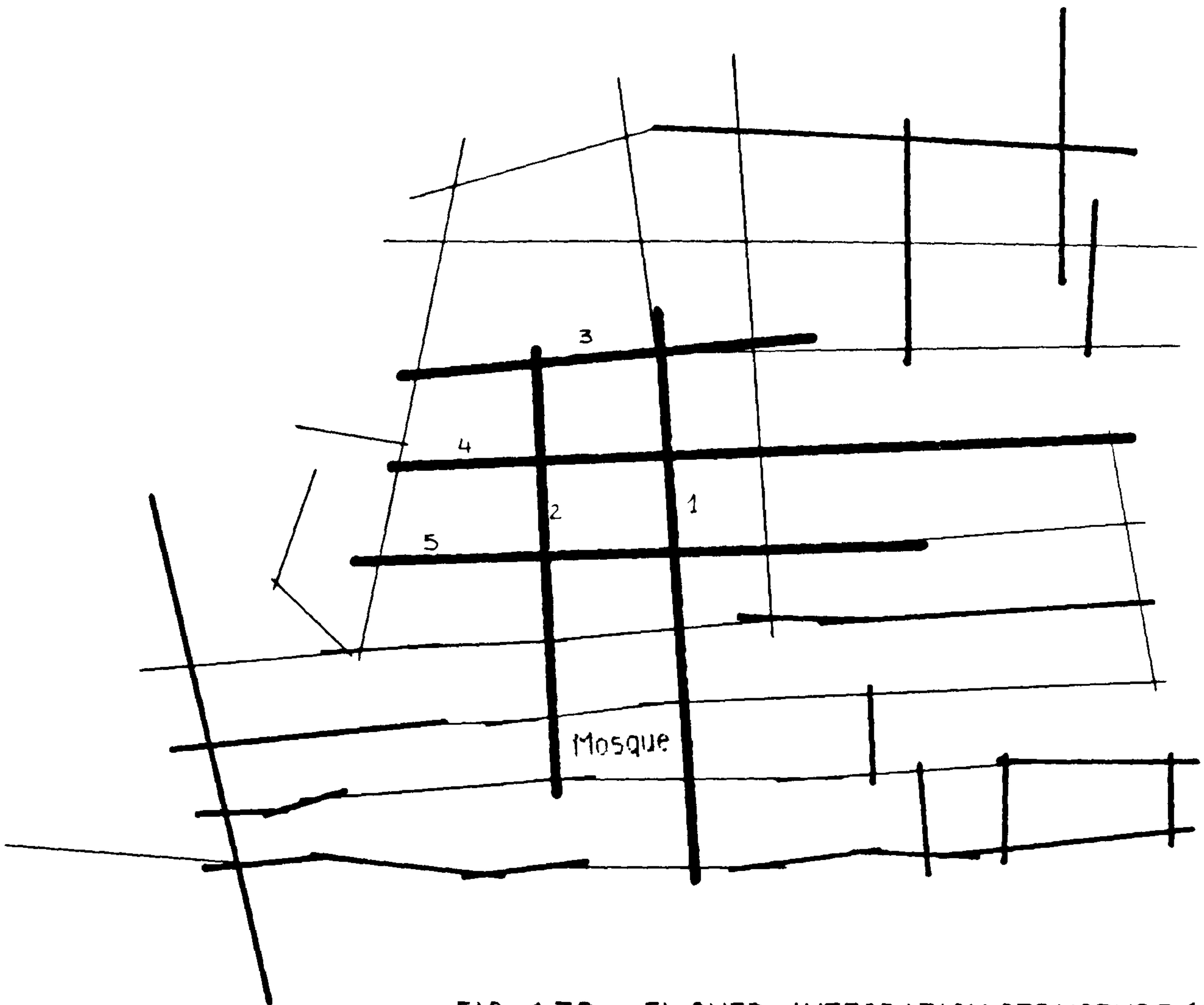


FIG. 4.32 : EL OUED, INTEGRATION STRUCTURE (EL01)

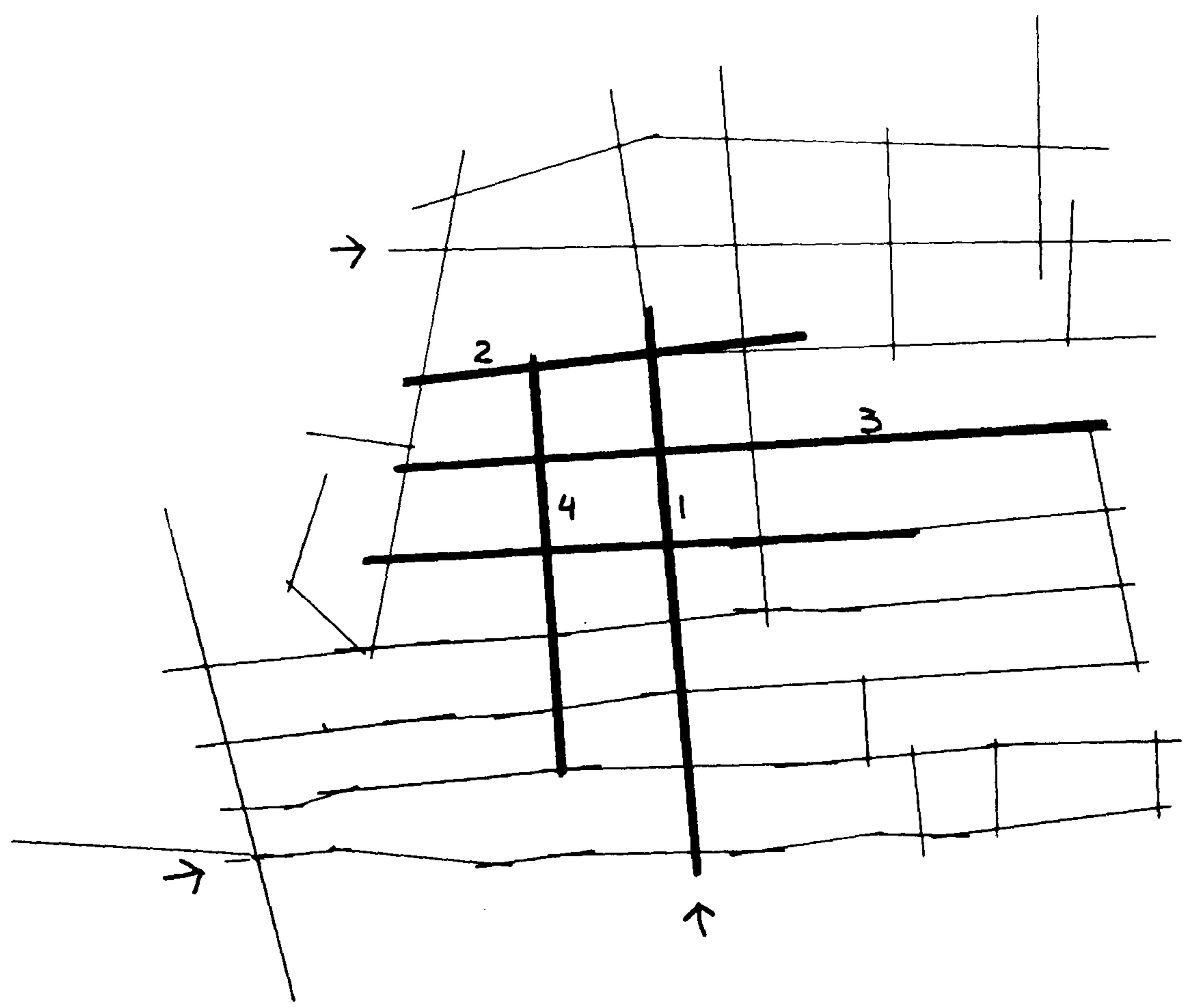


FIG. 4.33 : EL OUED, INTEGRATION STRUCTURE (EL02)

tern. The mosque and the few adjoining shops lie on the second best line in terms of integration.

The most segregated spaces, on the other hand, form three separate groups distributed around the integration core. The integration core of El Oued may be held to make the system more easily accessible. Most of the lines of the street system are not more than one or two axial steps away from the integration core.

Figure 4.33 shows the integration core of the system linked to the outside, which does not present important variations from the previous version. In both versions, the integration cores are constituted by the same lines. The first integrator remains the same, while the second and the third best line in EL01 become fourth and second in EL02. while radius-3 core (see fig. 4.34) consists of most spaces of radius-n core.

In conclusion, this settlement does not depend on the exterior for its integration, nor for its intelligibility and predictibility.

THE ANALYSIS OF SIMULATED MOVEMENTS IN EL OUED:

The choice structure:

Figure 4.35 shows the lines with strong choice quantities. These form a continuous structure in the centre of the settlement, with the most important line directly linking the area of the mosque and the local

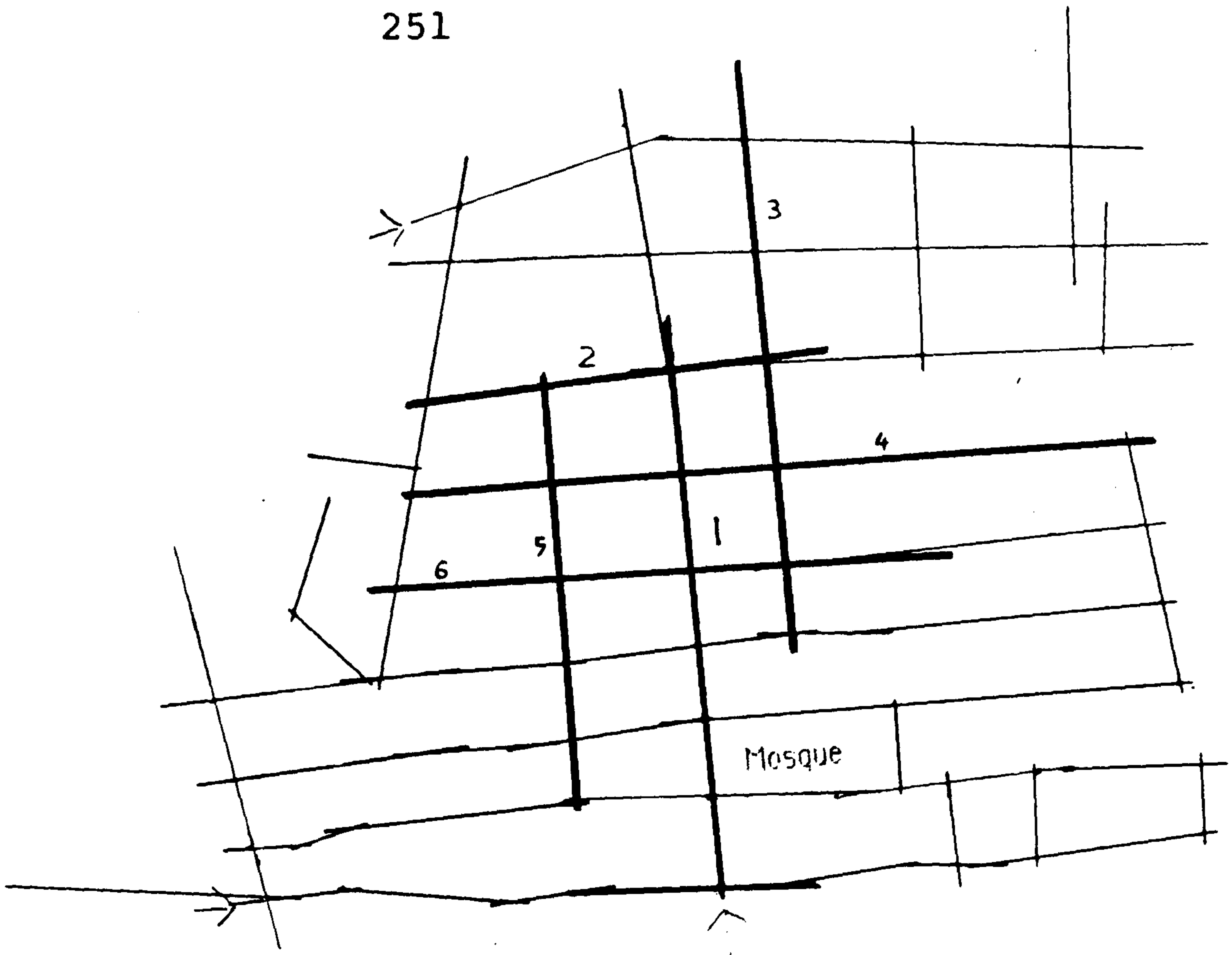


FIG. 4.34: EL OUED, RADIUS-3 INTEGRATION CORE

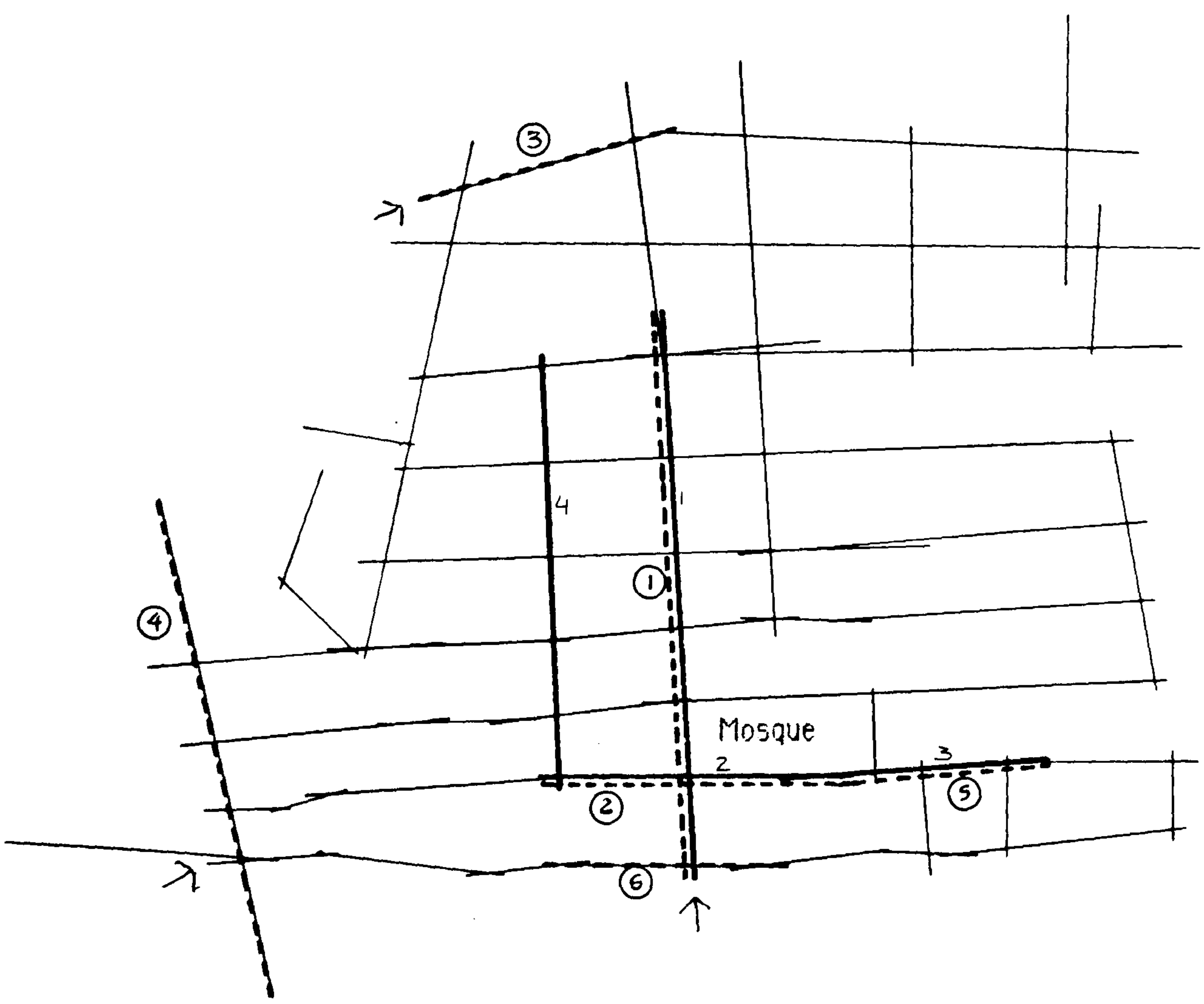


FIG. 4.35: EL OUED, CHOICE STRUCTURE

CHOICE STRUCTURE

RANDOM JOURNEYS FROM OUTSIDE

shops to the outside. This line has therefore emerged as the most accessible with respect to the settlement as a whole, the most permeable and also the most important in terms of simulated movements inside the system. The first, second and fourth lines in terms of choice intersect at the mosque.

Figure 4.35 shows also the best lines in terms of random journeys from the outside. The correlation between the choice quantities and the random journeys logged from the outside, amounts to 0.718 (with the journey quantities square rooted). Again, the mosque and the commercial street emerge as the most important elements for both simulated movements. This result points to the conclusion that for El Oued, there is a strong interface between the two types of simulated movements.

THE SPATIAL ANALYSIS OF THE ROOF TERRACES:

In Part One, it has been shown on the basis of the examination of the roof plans and other descriptive material that morphological differences existed between the roof terraces of the Mzab towns and Ghadames. It has also shown that there are important differences in the way in which women use the rooftops in these towns. The aim of this section is therefore to see the extent to which syntactic differences (if any) in the spatial configurations of the rooves might amplify these descriptive differences. It is suggested that the spatial differences that may exist between the terrace configurations may define the extent to which the terrace system might be held to be geared more towards facilitating than only permitting contacts between women.

This conjecture will be tested through the spatial analysis of the terraces in the two settlements: Ghadames where the system is developed to a high degree and Beni Isguen where the system exists only in a partial form. By this, it is intended to show that it is the way in which the terraces are spatially structured, which defines to a certain extent, the means and modes of communications among the women, such that a well connected terrace system creates more spatial relations and would therefore be seen to facilitate contacts. The degree of elaboration of the terrace system is therefore, not only described and measured in terms of the scale to which it exists, but also in terms of its internal structure, such as the degree of connectivity to immediate and more distant neighbours, and the structure of the integration core.

For this purpose, three roof areas have been selected, one in Ghadames in Wazit quarter, and two in the older part of Beni Isguen.

The results of the analysis of the street systems in Ghadames and Beni Isguen will constitute a background against which the spatial properties of the terraces will be contrasted, so that different levels of comparison can be achieved; that is on the one hand, a comparison between the spatial structure of the roof terraces and the streets within the context of the same settlement; and on the other, a comparison of the terrace system in the two settlements.

Several problems and difficulties have been encountered in the attempt to analyse the roof terrace system, one of which concerns the definition of space at rooftop level. Unlike the street system which consists of a continuous structure of open space clearly delimited by the building walls, the spaces used for circulation at the rooves already form part of the buildings. These are rooftops and sections of party walls separating the upper courtyards of the different houses. The spatial relation of "inside-outside" defined by a clear boundary between a building and a segment of a street is no longer appropriate, and acquires a totally different

meaning when applied to the roof terraces. In Ghadames, the wall which is used to separate individual households at roof level, is also the very means of relating the different households. When a woman is "outside" the upper courtyard, she is still in direct visual contact with anything happening "inside" the upper courtyard. There is always a visual continuity in the roofs
rooves.

Figure 2.10 inserted in Part One, shows a roof plan of an area taken from the quarter of Wazit in Ghadames. This plan formed the basis for the drawing of the axial map. Difference in levels (usually 2 to 3 steps high at most, see Pictures in Part One) between segments of spaces used for circulation has been disregarded in the graphic representation of these pathways: all spaces have been considered as being at one level.

The production of the axial maps has been carried out in two stages. First, all spaces used for circulation have been identified. These are all roof areas that are not skylights or bounded by high party walls. Second, using the resulting roof plan as a basis, an axial map is drawn. The examination of the axial maps of the roof areas in figures 4.36 and 4.37, shows a more fragmented axial organisation of the terrace system in Beni Isguen than in Ghadames.

The degree of elaboration of the terraces and the spatial restrictions existing in them will be mainly expressed in terms of the degree of connectivity and the degree of integration.

	GHADAMES(1*)			BENI ISGUEN				
	DARAR	WAZIT	TERR	BI1	BI2	TER1	TER2	TER3
NBER OF SPACES	67	50	98	264	249	39	75	123
MEAN CN	2.57	2.60	2.96	2.93	2.63	2.46	2.51	2.52
MAX. CN	5.00	5.00	6.00	13.0	7.00	4.00	6.00	6.00
MEAN RRA	1.45	1.32	1.37	1.28	1.92	1.72	1.69	3.46
MAX RRA	2.05	2.52	2.34	1.83	2.96	2.52	2.52	6.63
MIN RRA	1.02	0.80	0.99	0.80	1.36	1.12	0.99	2.34
ST.DEV.	0.24	0.33	0.36	0.19	0.34	0.34	0.36	0.99
1:RA/CN	0.55	0.61	0.55	0.38	0.37	0.25	0.41	0.20
RI(2*)	-.17	-.14	-.14	-.21	-.23	-.52	-.31	-.47
1:RA/RCH	0.79	0.71	0.64	0.53	0.62	0.87	0.77	0.31
R.PRED.	+.01	-.09	-.10	-.12	-.04	+.05	+.01	-.41
CN/CH	0.70	0.71	0.69	0.66	0.45	0.24	0.65	0.21

TABLE 4.11: MEASURES FOR THE STREET AND THE TERRACE SYSTEM, GHADAMES AND BENI ISGUEN

Table 4.11 presents the analytical measures for the terraces and for the street systems in Darrar, Wazit and Beni Isguen (BI1 and BI2).

The results are:

1* TER1 and TER2 to the two roof areas analysed separately in Beni Isguen, and TERR refers to the terrace area in Ghadames; BI1 and BI2 to the street system in Beni Isguen and TER1 and TER2 refer to the two roof areas of Beni Isguen, and when combined together they give TER3.

2* RI refers to the relative intelligibility of the systems calculated on the basis of the predicted value for systems of similar size. and R.PRED. refers to the relative predictibility of the systems calculated on the basis of the expected value for systems of similar size. R.PRED. refers to the relative predictibility given by the integration.

- the mean connectivity of the terraces in Ghadames is much higher (2.96) compared to both, the mean connectivity of the street system (2.57 in Darrar and 2.60 in Wazit), and the mean connectivity of the terraces in Beni Isguen (2.46 in Roof Area 1, 2.51 in Roof Area 2).

- for Ghadames, the maximum connectivity of the terraces is higher than for the streets.

- in Beni Isguen, the maximum connectivity of the terraces varies for the two areas; but in all cases, it remains below the maximum connectivity for the streets.

- The mean integration for the terraces (1.37) in Ghadames remains within the range of the level of integration of the streets (1.45 in Darrar and 1.32 in Wazit). But it is relatively better than the mean integration for the terraces in Beni Isguen (1.72 in Roof Area 1, 1.69 in Roof Area 2).

- The intelligibility of the terraces in Ghadames (0.55, -0.14) is of the same order as the intelligibility of the streets, but is much better than the terraces in Beni Isguen. The intelligibility of the terrace areas in Beni Isguen is very poor compared to the value predicted for a street system of the same size. In Roof Area 1, it only reaches 0.25 (-0.519), while in Roof Area 2, it is 0.41 (-0.304).

- The predictability given by the integration is below average for the terraces of Ghadames, when compared to the value expected for a street system of similar size;

but it is about average for the two terrace areas of Beni Isguen. Whilst, the predictability given by the connectivity is better for the terraces of Ghadames, but varies significantly for the terraces of Beni Isguen (0.24 in Roof Area 1, 0.65 in Roof Area 2).

Clearly, from a syntactical point of view, the terrace system in Ghadames can be described as more axially connected, less segregating and more intelligible than the terraces in Beni Isguen.

THE PATTERN OF INTEGRATION OF THE TERRACES:

The integration cores of the roof areas are shown in figures 4.36 and 4.37. In Ghadames, the integration core is constituted by a group of lines concentrated in the centre of the area, connected to the edges by several other lines. The core presents a structure which tends to cover and traverse the whole roof area in several directions. The integration core is made up of both types of spaces, the more elongated and the more square-shaped ones corresponding to the narrow paths and the wider kitchen rooftops. The most segregated spaces form three distinct clusters on the periphery of the surveyed roof area, and surround the integration core (see fig. 4.36).

For Beni Isguen, in Area 1, the integration core tends to form a linear structure across the system. An increase in the percentage of the most integrated

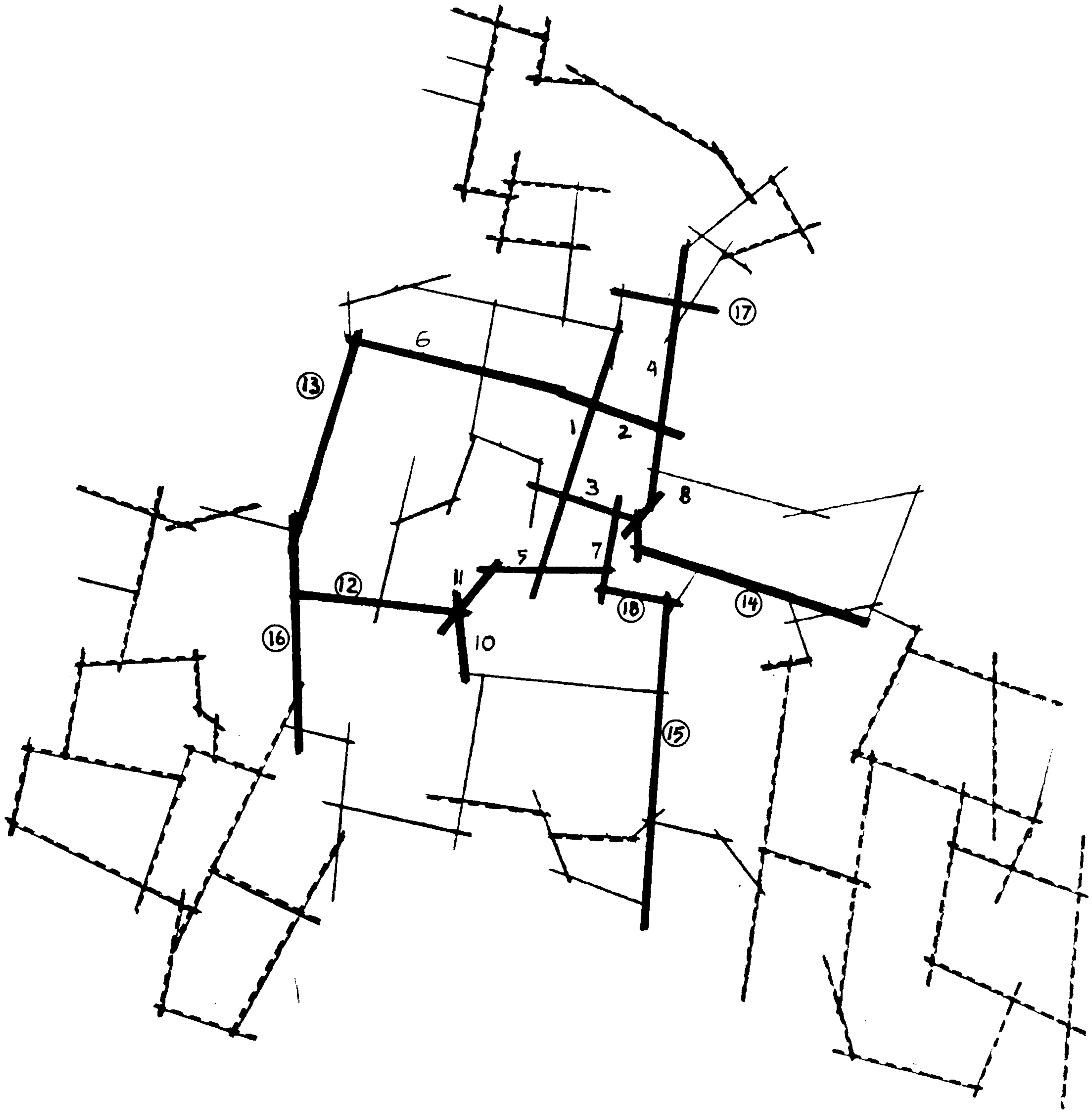
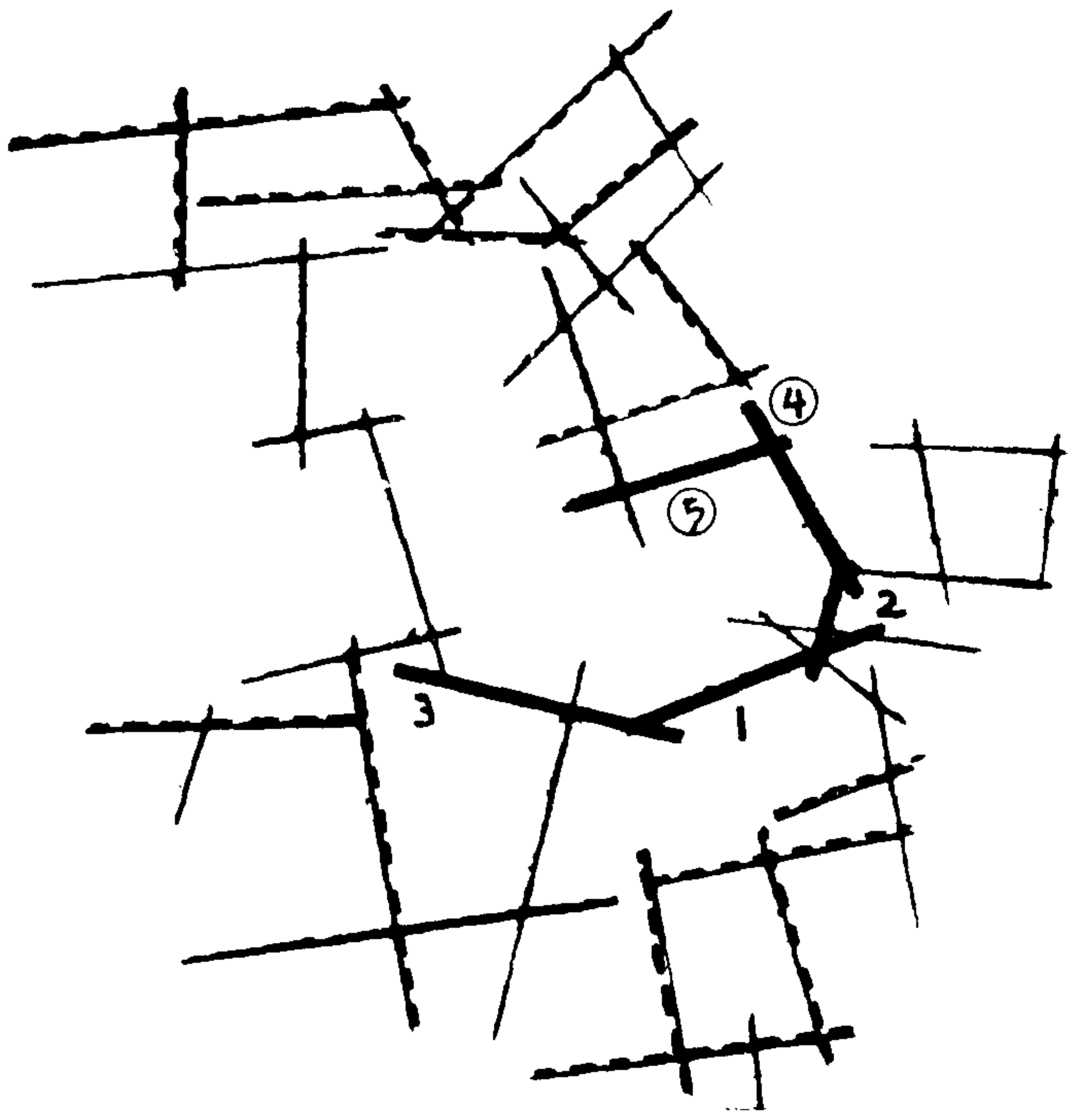
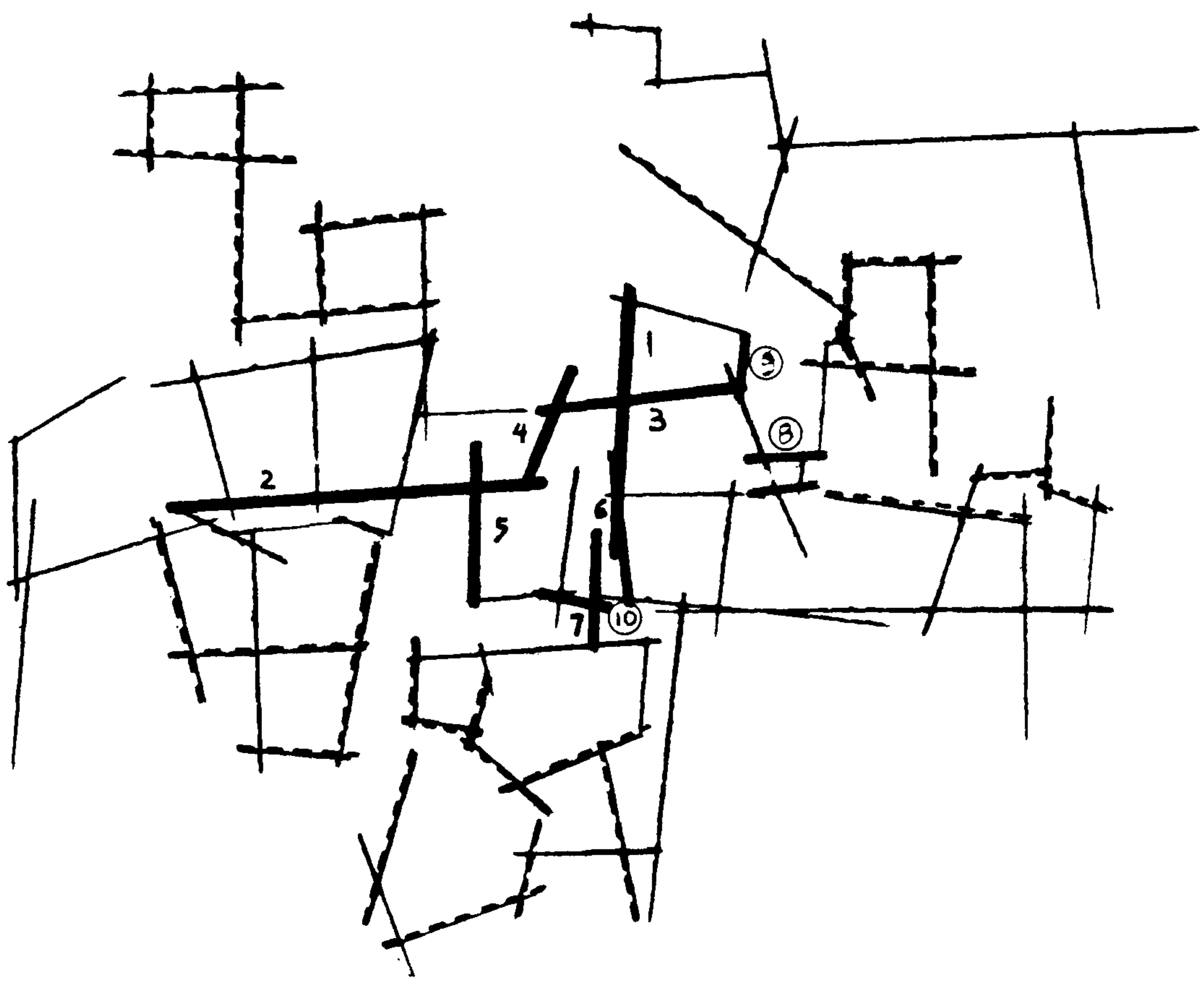


FIG. 4.36: GHADAMES, ROOF TERRACES

INTEGRATION CORE (10%)
12 INTEGRATION CORE (15%)
SEGREGATED SPACES



ROOF AREA 1



ROOF AREA 2

FIG. 4.37: BENI ISGUEN, ROOF TERRACES

INTEGRATION CORE.

INTEGRATION CORE

SEGREGATED SPACES

spaces reinforces this linearity. In Area 2, the core consists of a concentration of the most integrated spaces in the middle, with two long lines pointing to opposite directions towards the edges of the roof area. This structure can be also seen as expanding linearly. The cores for the two roof areas of Beni Isguen present then a structure which differs from the core of the rooves in Ghadames, in the sense that despite the linear development, the core forms a central axis without however covering the whole area. In both roof areas of Beni Isguen, the segregated spaces cluster around the integration cores, and at the edges of the islands.

The patterns of integration cores of the terraces in Ghadames and Beni Isguen, can then be seen to display relevant differences which may have some bearings on the way the terraces are used. The integration core in Ghadames tends to approach the covering type structure. The overall location and structure of the integration core in Ghadames shows in these respects, some similarities with the patterns found in the street organisation of this town. In Beni Isguen, although the cores tend to traverse the roof areas, they remain confined to the central zone.

In the light of the analytical results, it seems reasonable to suggest then that the morphological differences observed between the two terrace systems are to some extent, amplified by the syntactic differences.

The terrace system of Ghadames has shown to be axially better connected at the local level and at the larger scale: every axial line in the system is in average connected to about three other lines, and in morphological terms, every individual house is adjacent to at least two other houses (see Roof Plan in fig. 2.10). This makes every house or in social terms, every occupant (woman) is at least in direct spatial proximity to at least six other women. This is a simple indication of the potentiality of the terraces in Ghadames in permitting interactions between women, using only the spatial proximity of the terraces to establish such contacts.

In Ghadames, with the exception of Bellil area in which the core is peripheral, the analysis of the street system of the other three quarters has shown that the integration cores in these areas tend to approach the covering type. On the other hand, the analysis of the street system of Beni Isguen considered at different stages of growth or according to the three versions of mapping, has revealed linear and non-covering core type. The consideration of these results suggests a relation between the spatial structure of the street system and the terraces, such that the more the core covers the street fabric, the better the level of integration and intelligibility of the terraces and the more their core is also covering.

An inference can therefore been drawn in the light of the descriptive material and the results of the spatial analysis, that is the terrace system of Ghadames can be seen as geared more towards the increase of spatial proximity between women, and perhaps can be also held to be geared towards the generation and facilitating the contacts between them. In Beni Isguen, the poor level of axial connectivity, and the highly segregating structure of the terrace fabric, in addition to the restriction of the accessibility to the level of the block and the location of the kitchen and other female spaces at the ground floor of the house, all of these characteristics point to the suggestion that the terraces in Beni Isguen may be seen as only a "permissive" system, in the sense that it makes contacts between women across the rooves possible but not "natural". For example, the fact that the terrace links are restricted to the level of the island and are more limited inside the island, suggests a certain difficulty in generating more casual and "non-sought" encounters between women.

OVERALL REVIEW OF ANALYSIS AND SOME THEORETICAL SUGGESTIONS:

An overall review of the analytical section will be carried out by looking first at the underlying similarities between the cases and second, their fundamental differences.

	NBER SPACE	MEAN CN	MAX CN	MEAN RRA	MAX RRA	MIN RRA	1:RA/ CN	RI	1:RA/ RCH	RPRE	CN/ CH
GHADAMES											
MAZIGH	12	2.17	3	1.37	1.85	1.21	.76	-.10	.87	-.04	.69
BELLIL	20	2.15	3	1.93	2.68	1.42	.67	-.15	.89	+.01	.86
WAZIT	50	2.60	5	1.32	2.52	0.80	.60	-.15	.71	-.09	.71
DARRAR	67	2.57	5	1.45	2.05	1.02	.55	-.17	.79	+.01	.70
GHAD1	160	2.50	5	2.29	4.37	1.36	.46	-.19	.46	-.24	.46
GHAD2	161	2.54	5	1.47	3.05	0.80	.49	-.16	.52	-.18	.56
TERR	98	2.96	6	1.37	2.34	0.99	.55	-.14	.64	-.10	.69
GHARDAIA											
GHARD1	63	2.50	5	1.51	1.79	1.18	.52	-.21	.65	-.14	.62
GHARD2	171	2.50	6	1.76	2.85	1.22	.48	-.16	.65	+.01	.70
G1	320	2.78	13	1.57	2.26	1.13	.46	-.11	.47	-.16	.58
G2	307	2.71	12	1.76	2.72	1.23	.42	-.16	.50	-.13	.55
G3	308	2.75	12	1.44	2.12	0.88	.52	-.06	.52	-.11	.69
BENI ISGUEN											
BENIS1	79	2.58	5	1.46	2.12	0.92	.59	-.12	.74	-.02	.66
BENIS2	123	2.73	5	1.61	2.22	1.15	.35	-.32	.62	-.10	.56
BI1	264	2.93	13	1.29	1.82	0.80	.38	-.21	.53	-.12	.66
BI2	249	2.63	7	1.92	2.96	1.36	.37	-.23	.62	-.04	.45
BI3	250	2.66	7	1.79	2.84	1.29	.40	-.20	.68	+.02	.45
TER1	39	2.46	4	1.72	2.52	1.12	.25	-.52	.87	+.05	.24
TER2	75	2.51	6	1.69	2.52	0.99	.41	-.31	.77	0.00	.65
ELOUED											
ELO1	44	3.55	9	0.85	1.28	0.47	.73	-.03	.74	-.07	.76
ELO2	45	3.57	9	0.79	1.26	0.41	.73	-.03	.78	-.03	.66

TABLE 4.12: GENERAL DATA TABLE FOR ALL CASES

GHAD1 refers to the system of Ghadames as a whole without the connections to the outside, GHAD2 refers to Ghadames connected to the outside. TERR: Roof Area in Ghadames. GHARD1: Ghardaia at the first stage of growth, GHARD2: Ghardaia at the second stage of growth, G1: Ghardaia as a whole with the peripheral spaces inside the walls, G2: Ghardaia without the peripheral spaces, G3: Ghardaia with the connections to the outside. BENIS1: Beni Isguen at the first stage of growth, BENIS2: Beni Isguen at the second stage of growth, BI1: Beni Isguen as a whole with the peripheral streets, BI2: Beni Isguen without the peripheral streets, BI3: Beni Isguen with the connections to the outside, TER1: Roof Area 1 in Beni Isguen, TER2: Roof Area 2 in Beni Is-

Table 4.12 gives a summary of the numerical properties for all towns at their different stages of growth, their different states of representation as well as the roof areas. It shows underlying similarities between the cases, but also strong variations.

Clearly, the basic measures and their statistical derivatives indicate that the towns with the terrace system, either fully or partially developed, when considered as a group present distinctive properties. Their spatial fabric can be characterized as highly segregating in all versions of representation and at all stages of growth, with a poor level of intelligibility. El Oued on the other hand, presents the opposite properties; it is a much more integrating and intelligible system. Conversely, Bellil, the other system where the terraces do not occur, has the lowest integration of all small areas, a weak intelligibility but an average predictibility. These variations suggest that the degree of integration and intelligibility of the systems does not relate in a single way to the existence or the differential appearance of the terrace system.

The analytic results have also shown strong variations between the different cases. These can be summarized as follows:

For Ghadames, the connectivity (mean and maximum) does

guen. ElO1: El Oued without the connections to the outside, ELO2: El Oued with the connections to the outside.

not vary markedly with size, and is not affected by the connections of the system to the outside. The level of integration of the small systems is by far better than for the town as a whole. This mirrors the physiognomy of the town which is made up of four areas almost entirely isolated from each other. The system of Ghadames seems to have evolved by adding more elements without adding more structure in order to control the effect of growth.

This is not the case for Ghardaia, where the system tends to improve the connectivity (mean and maximum) as it grows, while retaining the integration constant. Therefore, in Ghardaia the effect of growth seems to be controlled for through the increase of the maximum connectivity of some spaces, which creates and maintains a certain level of integration. The removal of the peripheral spaces and the connections of the system to the outside has led to the conclusion that the increase in the connectivity is not assigned to the periphery of the town, but is more internal.

For Beni Isguen, the mean and maximum connectivity also improve as the system grows larger, but unlike Ghardaia, the increase in the connectivity is only invested in the periphery, in which case the removal of the peripheral streets affects strongly both the mean and the maximum connectivity. The system depends also on the periphery, but not on the connections to the outside, for its integration. Therefore, the system of

Beni Isguen seems to overcome the effect of growth by increasing its connections to the periphery.

The spatial analysis has also shown fundamental differences between the towns in terms of the structure of their integration cores.

The integration core of Ghadames seen as a whole does not cover the whole fabric, but is confined to the area of the market square and the main mosques. Therefore from the point of view of the town as a whole, the market and the mosques are the dominant elements in the integration system, and the core can be characterized as a non-covering and peripheral type. But, the integration cores of the small systems with the exception of Bellil quarter, present a structure which approaches the covering core type, and includes in all three cases, the streets where men sit. For Bellil, the core remains at one edge of the quarter and includes the quarter's mosque. For the terrace area of Ghadames, the core takes a much more covering form, linking the edges to the centre of the area in several directions.

For the small systems of Ghardaia, the core remains non-covering and the spatial structure exhibits the two-sidedness effect in the overall organisation. At the first stage of growth of Ghardaia, the mosque comes out as the most important element in terms of integration. In the second stage, the core links the small market square to the mosque and the market becomes then the dominant feature. In the large system, the two-sidedness effect is firmly established; the core is more peripheral and non-covering. The analysis of the town according to the different states, has shown the strong dependence of the market on the connections of the town to the outside. The mosque on the other hand, remains highly segregated with respect to the outside. The removal of the peripheral streets (G2) affected strongly the internal structure of the core, the mosque becomes much less segregated and the core runs more from the mosque towards the market area than from the market to the mosque and to the outside (as seen in G1). Radius-3 integration has shown that the system of Ghardaia tends to emphasize its global structure as it grows bigger with the market area remaining a strong integrator at both levels of organisation, local and global. The simulation of the movements inside the town (Choice) has shown the predominance of both the market and the mosque, but only the market has emerged as the strong interface space for the internal movements and the movements originating from the outside.

For Beni Isguen, the cores of the small systems remain internal and non-covering, with the mosque and the market as the dominant elements strongly connected to each other, but not to the outside. In the larger system, the spatial structure becomes more complex and presents two types of cores: one peripheral and located away from the town public facilities (BI1); the other internal and also non-covering which intersects the market square and runs in the direction of the mosque (BI2). The market of Beni Isguen is also highly dependent on the connections of the town to the outside, but unlike Ghardaia and Ghadames, it remains not directly connected to the outside. Similarly to Ghardaia, the mosque in Beni Isguen is strongly segregated with respect to the outside (BI3). The town exhibits also strong local structures that are highly segregated with respect to the whole system. This is a distinctive feature to this town which suggests that Beni Isguen and contrarily to Ghardaia, tends to take on a much more localized emphasis as it grows larger. The simulation of movements inside the system (choice) has shown two potential routes, one peripheral (BI1) and the other more internal (BI2) with the predominance of the market. In this case and contrarily to Ghardaia, the mosque remains isolated from these routes, and only the peripheral streets have emerged as the interfacing elements for the internal movements and the random movements from the outside. The cores for both roof areas of Beni Isguen tend to be more confined to the central part, and therefore much less covering than the core of the roof area in Ghadames.

For El Oued, the situation is completely reversed. The system presents a grid-core type, which traverses entirely the fabric in several directions, and does not create relatively more segregated areas. Instead, most spaces are only few steps away from the core. The mosque and the shopping street are strongly connected to the outside and form the dominant structure in terms of integration.

Despite the limited number of cases looked at in this study, the above analyses have demonstrated three distinct types of spatial organisation on the basis of the structure of the integration core: i- the covering core; ii- the non-covering core which may be either peripheral or internal; iii- the grid-core type. These seem to have possible relevance in understanding the way in which these urban forms may relate to the social use of space by men, women and strangers, as described in Part One of this report.

In the small systems of Ghadames, the spatial structure of the quarters mirrors the space uses by men-residents and women. The core of each quarter, except for Bellil, traverses the fabric and passes through the areas where men sit and gather, and near the buildings (i.e. mosques) mainly intended for men's uses. The core can be seen therefore to be oriented more towards the men of the quarter. The local cores (radius-3 integration cores) include also many of the streets intended for men's meetings. By doing this, the spatial structure of the street system can be seen to contribute by its very nature in keeping the women away from the streets. On the other hand, the terraces provide a highly integrating system for women; the terrace core has the tendency to facilitate the movements of women across the quarter, by directly linking the edges to the centre. For Bellil, the spatial structure seems also to relate to the differential space uses by men and women. The peripheral core incorporates the mosque of the quarter where men mainly congregate. The streets used by women are carefully segregated from these areas. For Ghadames as a whole, the core intersects the market area with the two most important mosques of the town. This is a male-oriented space per excellence, where men from the different quarters and strangers meet, and where transactions take place (selling and buying goods, meeting place for the Friday prayer...). The spatial structure of Ghadames may then be seen to emphasize more the local level of organisation than the global, by integrating much more strongly the men of the separate quarters.

In the case of Ghardaia, the analysis (G1 and G3) has shown that the market square and its adjoining area are the main integrating elements with respect to the outside. The descriptive section on space uses has shown that the male inhabitants meet with the strangers in the business and commercial area. Its direct link to the outside makes then the access of the strangers much easier. The spatial structure of the town appears therefore to allow the strangers into the system, but restricts them to specific areas, to the area where the integration core is located; that is away from the main mosque which has emerged in spatial terms as strongly segregated with respect to the outside (G2), but as the second most popular area from the simulation of internal movements. Therefore, the mosque can be regarded as more oriented towards the use of the male-inhabitants. This result is consistent with the ethnographic material, in which it has been reported that the main domains of interactions and activities for the male-residents were mainly concentrated around the mosque and the market place. On the other hand, the comparison of the analytic evidence with the ethnographic data suggests a possible relation between the two-sidedness characterizing the global organisation of this town and the use of women of some streets, that is the development of the "zenka unit". The peripheral location of the integration core and its non-covering nature would leave, by its very nature a large "zone" of the town entirely segregated with regard to the movements of strangers. This associated with the local custom which requires the men-residents to leave their home area during certain hours of the day can be seen, using the spatial evidence alone, to contribute in reducing the male movements through the segregated "zone", and may explain the simultaneous and separate use of space by the two sexes observed in this town.

For Beni Isguen, the situation is rather different from Ghardaia. The spatial structure presents in global terms two integration cores, the first located on the periphery, and might be expected from the spatial evidence only to be mainly used by the strangers and also by the inhabitants moving to remote destinations. In other words, the settlement by virtue of its overall spatial organisation, appears in these terms to contribute in controlling the strangers by keeping them away on the edge of the town. The second core, more internal and requiring much more knowledge of the spatial structure, develops across the market area, which is according to the ethnographic data more used by the male-inhabitants and the strangers who have been admitted into the town. The market square may therefore be regarded as the second stage for interfacing the male-inhabitants and the strangers; that is not only the strangers may meet with the inhabitants on the edge but also at the market place, though this latter remains not strongly linked to the outside to facilitate its accessibility. In this case also, the spatial evidence mirrors the social uses of space observed in this town.

The structure of the core of Beni Isguen leaves also clusters of spaces strongly isolated with respect to the town as a whole, but which are highly integrated locally. The simulations of internal movements and movements from the outside point to the same conclusion; that is large parts of the town are left uncovered by the resulting patterns of movements. The non-covering core types, the local strong areas and the particular arrangement of simulated movements, all of these properties point to the conclusion that the system of Beni Isguen can be seen to reflect the space uses by the sexes in this town, and perhaps even explain the development of the "zenka" system, in the sense that men -residents and strangers- would tend to move along the cores, and women would tend to use more the globally-segregated and locally-integrated parts of the town. This is so mainly because large areas of the urban fabric appeared from the spatial evidence alone, to be kept away from the movements of men, residents and strangers, reducing therefore the potential interference and overlap of space uses by the sexes. The spatial structure of the terraces may also be held to contribute to the social use of streets by women. The central position and the non-covering core of the roof areas of Beni Isguen can be seen to be geared more towards the controlling than the generation of spatial relations between women; and by this, these terraces may be seen to complement the "zenka uses", mainly because this female domain can be theoretically characterized from the spatial evidence, as an insufficient basis for women to develop denser encounter patterns. This remains only a conjecture and more research is needed to substantiate this hypothesis, especially with regard to the degree of development of the "zenka" system in Ghardaia and Beni Isguen and its location in the urban fabric.

The spatial structure of El Oued on the other hand, may be seen as geared more towards facilitating the movements of men through the system and their interface with strangers. All spaces are very close to the core and therefore can be seen as oriented more towards the public and male uses.

From the analytical evidence, a clear picture starts to emerge regarding the nature of the possible relationship between the social uses of space and the spatial structure of the towns, especially the way in which these construct and control spatial relationships between men-women and inhabitants-strangers. In this respect, the spatial accessibility and the amount of choice appeared to be the key properties in introducing differentiation between the categories of users and controlling their interface. The spatial structure of the towns can be seen to allow the differential forms of space uses only because,

- it establishes strong differentiation between the spaces used by men-women and inhabitants-strangers, by means of controlling their degree of accessibility, that is their degree of separation and integration with respect to each other and with respect to the outside; and

- it imposes restrictions on movements by means of controlling the amount of choice and reducing the potential routes and thereby controlling the degree of interference of one group with another.

The spatial analysis has shown that there is a control of the overall degree of accessibility; the integration measures are well below average. It has also a definite distinction in the global organisation of the towns; the structure of the integration cores of the systems seen as a whole, is always realized in such a way that it leaves large areas which are mainly residential, not easily accessible. By locating the integration core in a particular area, the settlement can be seen to introduce differentiation between the categories of users. By doing this, the settlement defines and maps the categories of spaces assigned to the male resident population which are mainly the areas around the market square and the mosque, and controls the accessing of the strangers by restricting them to the area where the core is located, i.e. the market place and its surrounding area.

A logical implication of such a global organisation is that, the integration core by its very nature, creates highly segregated areas. The underuse of these spaces by men, might explain the "zenka" uses by the female population which is more bound to the areas around their homes. Therefore, the global structure of these towns can be described as potentially inclined to engender a clear spatial differentiation between the user categories, not only by a rigid spatial classification of spaces, but also by the control of the overall degree of accessibility.

But, the differential use of space by men and women may be also related to the degree of interference and overlap of space uses of one group with another. The simulation of the males' movements, whether it concerns the inhabitants or the strangers, has revealed consistent patterns of the overall arrangement of the "traffic" within the towns. For the extreme case of most parts of Ghadames, the problem of interference does not rise; the settlement offers a strongly connected and fully developed terrace system completely insulated from the movements of men.

In the case of El Oued, there seems to be a clear lack of such a property: the lines on which both the inhabitants and the strangers are likely to move, traverse strongly the system and pass close to most parts of the spatial fabric.

For Ghardaia, the movements of the male inhabitants have shown a tendency to concentrate on the southern part of the town, at the market place and around the main mosque. The movements of the strangers also tend to concentrate at the market square and near the southern edge. This particular arrangement would leave on the basis of these results, an entire zone relatively free from the movements of the men.

Finally, in the case of Beni Isguen, although the way in which the settlement space is reported to be used by the sexes remain similar to Ghardaia, the means by which this is realized in space seem to be substantially different. The simulated movements of the male-inhabitants tend to concentrate on the peripheral streets inside the fortification walls and at the market place. The movements (given by simulation) of the strangers tend also to cluster on the edge and at the market in the way described above. The spatial analysis of the hypothetical movements in Beni Isguen has then shown that this particular arrangement of the potential routes for the men would also leave large areas isolated from their movements.

By this, the spatial structure of these towns can be seen to contribute in the structuring of the social groups, by permitting a spatial separation of their domain of interactions, and also the possibility for the two groups to meet independently.

A general socio-spatial model begins to emerge on the basis of the evidence provided by the ethnographic material and the analytic studies, such that the more the integration core is peripheral and non-covering, the more the men-residents would be restricted to particular parts of the town, and the more their interface with strangers would be controlled and located at a specific area (usually the market place), and the more women would tend to develop the "zenka" system and the more the terraces become a "complementary" spatial basis. Conversely, the more the integration core approaches the form of a covering type, the more the system would be geared towards male's uses and the accessing of strangers, and the less there would be highly segregated parts, and therefore the more the terraces become a necessary spatial basis for women, or they would be more confined to their homes in the case of an absence of the terrace system.

Therefore, it can be concluded that the analytic results have lent suggestive supports to the hypothesis concerning the possible relationship between the differential uses of the settlement space and the spatial structure of the towns, and the question that arises from this is to see the extent to which these observed properties can be seen to result from the way these towns may have grown and the nature of the spatial rules and constraints that may have been followed during the growth process. The reason underlying this suggestion is that the spatial rules of building combination can be seen to some extent to express social constraints, in the sense that they may be spatial analogues to social rules; and if so, it suggests a spatial way to look at the nature of the relationship between spatial forms and social structures. This particular question will make the main concern of the next chapter.

SUMMARY TO CHAPTER FOUR:

The concentration of this chapter on the structuring of urban space and its possible relationship with the observed social uses of space, has revealed a number of spatial characteristics that held constant for the towns with the terrace system, either fully or partially developed; but also strong spatial variations between the cases.

The first property is the low levels of integration which seems to be created by the fragmentation of the axial organisation of the systems and the poor level of connectivity.

The second property is the weak correlation between connectivity and integration measures. With the exception of El Oued, all systems looked at locally or globally or according to different versions of mapping presented to a varying degree, a poor level of intelligibility, which has been found to be strongly dependent on the integration.

The third property is the consistent relation between the terrace development and the spatial structure of the towns, such that variations in the structure of the integration core was accompanied by variations in the degree of elaboration of the terraces and variations in the uses by men and women, suggesting therefore a possible relation between the structure of the integration core and its location on the overall urban fabric and the differential space uses by the men-residents, women and strangers.

The fourth property is the characteristic pattern of growth of these towns, which, while showing individual features, these systems consistently maintain the above characteristics constant as they grow larger.

This chapter has therefore demonstrated the existence of distinctive spatial features, which are, it is suggested, related to the ability of the settlement in accommodating differential forms of space uses, in the context of a clearly defined set of social rules.

PART THREE: A GENERATIVE MODEL

CHAPTER FIVE: A MODEL OF SETTLEMENT GROWTH

INTRODUCTION:

This chapter addresses itself to the questions about the nature of the spatial fabric of the towns and their global organisation that have been identified as distinctive to these systems, and their relationship to the form generative processes and the nature of the underlying generative rules.

The spatial analysis of the towns has shown a precise way in which these system differ from other urban forms (i.e. the 75 urban areas). The towns in question are characterized, first, by a highly segregating fabric which is less intelligible and in general less predictable, and which is also affected by size, though only marginally; and second, by a clear regionalization in the global organisation and the lack of covering integration core.

The morphological characteristics, (such as the winding streets, the inconsistency in block sizes and shape, the irregularity of the town layouts and the lack of formal and geometrical properties that are normally associated with conscious planning and design), indicate that the systems of interest are likely to have evolved more additively. Moreover, the numerical properties and in particular the segregating nature of the town fabric seem to result from the fragmentation of the axial organisation of the systems and a more locally-based distribution of the connectivity. It is suggested that these distinctive properties may be the result of the way in which the towns grew.

On the other hand, the pattern of integration and the non-covering cores, seems to be another effect of this localized pattern of distribution of connectivity. The reason underlying this suggestion is that a covering core seems to result from more globalizing rules imposed on the growing systems. The fact that the maximum connectivity of the systems that produce the covering core type, correlate strongly with size, while the mean connectivity and the mean integration are held constant, suggests that a super-order may have been introduced and imposed on the evolving systems (SERC Report, 1986, pp. 9-10). If this is the case, then and by reasonable inference, a non-covering core type is likely to be the result of a more locally based process of form generation.

Therefore, the main hypothesis that can be formulated is that the form generative process of this family of settlements may lack the kind of global rules that are conjectured for the 75 systems, and may be based on more localized rules within an otherwise random context. It is conjectured that it is this more localized generative process, which may create the low level of integration, the poor intelligibility observed in the settlements under study. Moreover, the fragmentation of the street structure and its poor connectivity, may be also created by this form generating process. This is intrinsically related to the block formation and possibly to the terrace morphology.

The main concern of this chapter is to test the extent to which the properties observed in the towns in question and summarized above, can be seen as a result of the generative processes. This will be investigated through the development of a cell-growth model which allows variation in the local rules restricting an otherwise random aggregation, but specifies no global rules. Local rules are rules governing the relation of a cell with its immediate neighbours, and global rules are rules operating above that level.

The aim of this part of the research is therefore to offer, through the development of a model, some insights into the type of generative spatial principles, that can lead to this settlement type and the way in which they acquire their general form, and therefore throw some light on the prevalent spatial characteristics and perhaps on the peculiarities of the terrace system. It aims to represent the town morphology in its simplest, its most "stripped-down" form. This section is mainly based on an analytical approach, using the idea of generative syntax to establish the description of the spatial order, and concepts dealing with the type and quantity of space invested in particular types of spatial relations.

The chapter is divided into three main parts. First, the question of the process of growth is located within a historical context, in an attempt to identify the kind of rules and building constraints, in purely formal terms, that may have been followed in the building activity of the towns. The historical material used in this section goes back to the medieval times, and includes a compendium of case studies of conflicts and disputes between neighbours about building activity during the 14th century. From this historical data, it is hoped to extract spatial information concerning the scope and the nature of the rules for growth and building development.

The second part of the chapter will deal with the presentation of the computer model itself and the rules that are embedded in it, as well as a range of variation on these rules, followed by a descriptive discussion of the morphologies generated by these rules. The third part will be concerned with the analysis of these computer generated systems and their comparison with the real examples.

HISTORICAL BACKGROUND:

The goal set out for this section is to try to use historical material as a basis to explore the building and planning principles which shaped this class of settlements. This kind of information would, it is hoped, help to define the rules that will be implemented in the model.

Very little material exists on this question, but the historical data which follows is based on one primary key source. This is the manuscript written by a master-mason, Ibn Arrami, during the 14th century about the building activity in the Medina of Tunis and Qairawan (Ibn Arrami, 1913). The manuscript is a compendium of a series of case studies of disputes between neighbours on the subject of problems caused by building development (*). It also includes solutions he brought to the problems under the guidance of the Qadi of the town. But the difficulty of acquiring a copy of this document, has forced the use of other studies in which the key reference document has been Ibn Arrami's manuscript. These secondary sources are:

i- A key article written by R. Brunschvig in 1947, entitled "Urbanisme medieval et Droit Musulman", with special emphasis on the rights and obligations of adjacent neighbours (Brunschvig R., 1947, pp.127-155).

ii- A recent publication by B.S. Hakim, in which most of the information concerning building development control was derived from the above manuscript (Hakim B. S., 1986).

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* There is one copy in Rabat, Dar Al-Khizanah Al-Ammah, No. A802834, Morocco; which has been borrowed by Harvard University.

iii- Finally, a Ph.D thesis by Al-Hathloul, dealing with the legal and normative (legislative aspects) system as the truly legitimate basis for the understanding of the process of formation and change of the "Arab-Muslim city". He also heavily relies on the same historical document as the two previous authors (Al-Hathloul S.A., Ph.D Thesis, 1981).

A thorough search has been undertaken in an attempt to see if similar documents existed about other towns in the region. B. Hakim proclaims remarkable similarities between cases in other towns of the Maghreb region taken from other sources (*). which he has checked (Hakim B., 1986, p. 23). However, many of these sources are originals and only very few copies are available for consultation.

These references are especially valuable sources for the reason that they provide a unique record of the building activity in a "Medina" type of settlement, during mediaeval times. They are very informative about the process of growth, and offer a useful basis from which to examine the building process and

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A search was undertaken by the author to trace the sources referred to by Hakim, but without success. These are Sahnun's compilation (854) entitled "Al-Mudawwanah", 16 vols, Cairo 1905; Al-Wansharisi (1508) entitled "Al-Miyar Al-Mu'arab wa Al-Jami' Al-Maghreb an Fatawi ahl Ifrikiyah", 12 vols printed lithographically in Fez in 1896; and Ibn Al-Imam (996). Only one reference has been located and checked. This is the manuscript written by Isa Ibn Musa called Ibn Imam, which was translated from Arabic into French by Barbier De Meynard in 1900. A copy of the manuscript itself exists at the National Library of Algiers, No. 1292.

development, and try to identify the regulations followed by the individuals in their building acts.

The morphological information intended to be extracted from the review of these sources relates mainly to issues dealing with the urban fabric, such as follows:

i- Building contiguity or relationship between contiguous buildings; (i.e., what are the conditions and constraints imposed when attaching to an already existing building? Is it a right or a privilege to use the neighbours' wall to build one's house?). This, it is hoped, will provide the basic information concerning the aggregation of contiguous buildings.

ii- The street system and more precisely the relationship between the building and its immediately adjacent exterior space (i.e., what are the regulations concerning the extension of a building into a street? Is it permissible or a forbidden act to build on spaces designated for public circulation? What is the minimum right of way of streets and pathways? And does the exterior space belong by right to the building which abuts on it?..).

iii- The relationship between buildings on opposite sides of the street (i.e., What are the regulations and constraints of the positioning of a building on the opposite side of an already existing building? Are there particular practices as to the position of openings facing another existing building?).

The multitude of cases of legal disputes due to conflicts between neighbours centred primarily around housing and accessibility, and these disputes had to be resolved expeditiously. According to the above authors, Islamic law constituted a framework for adjudicating related conflicts. These disputes related mainly to problems concerning:

i- the street system, the right of way and its related elements.

ii- the use of the party walls in terms of right and obligations.

iii- the problem of overlooking

Other problem issues were related to the norms of comfort and locational restrictions of some uses causing harm due for example, to smoke, offensive odours, evacuation of waste water.

i- THE STREET SYSTEM:

Brunschvig notes that the question of the streets and pathways, in the context of the "neighbourhood regulations" (Droit de voisinage), whatever their nature, is much more related to the study of the private property rather than to the public right (R. Brunschvig, 1947, p.131). By this, he refers to the notion of "fina" pointed out in the compiled manuscript, which is the exterior space immediately adjacent to the exterior wall of a house. The right of usage of the "fina" belongs to the owner of the house or the building which abuts on it. This space is allocated (by right according to both, Brunschvig and Hakim) for the daily use of the inhabitants without allowing the construction of building on it (*). The allowed uses of the "fina" by the inhabitants are the loading and unloading of beasts of burden and the temporary parking of such animals (Hakim B., p.27; Brunschvig R., p.131). This particular notion of an exterior open space always allocated and attached to a house (or a building) is of an important relevance to the definition of the rule of accessibility in the ensuing sections.

According to the historical documents, the width and height of streets are clearly determined by the mode of transport used during the mediaeval times. The size of streets must allow the passage of a fully loaded camel with a rider (Hakim B., 1986, p. 21). The building over the street is determined, according to the historical document, by the need for extra space of building, particularly housing which created the "sabat", which is a room spanning the street (Ibid, p. 66). However, in some cases it becomes a succession of rooms creating continuous coverage and a tunnel effect of a street. The covering of the street is also referred to as a

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* There is a case study in the compiled manuscript where the extension of a building into a street was forbidden: Sahnun, the Qairowan judge strictly forbade any encroachment upon the streets; Brunschvig R., 1947, pp. 131-132).

means to provide shade and protection against the sun for street users (Ibid, p. 66). Many cases were reported regarding the extension of houses over the street and conflicts arising from the use of the opposite wall to implement it (Ibid, p.29).

ii- THE PARTY WALL:

The wall separating private households is either privately or collectively owned. The usage of an already existing wall is not a right as it is in the Roman legal system, but a very well established practice (Brunschvig R., 1947, pp. 137-138). Brunschvig has particularly compared the Roman to the mediaeval Muslim legal system and states clearly that in Rome, a building owner cannot legally prevent the neighbour to use his wall for expansion (Ibid, pp. 137-138).

In case of a dispute about a wall ownership, various solutions have been adopted, most of the time requiring joint agreement between the neighbours (Hakim B., 1986, pp. 39-45). This is a clear indication of the existence of a strong interdependence between neighbours with regard to the use and rights of party walls. This interdependence is an inevitable consequence of two factors: first, the organisational principle of the domestic space: the courtyard house type; and second, the shortage of land for construction, another inevitable consequence of settlements walled for defensive purposes. As a result of this configuration, a shortage of land is bound to take place as the settlement grows larger.

iii- OVERLOOKING AND "VISUAL CORRIDORS":

One of the main problem issues for disputes between neighbours during the mediaeval time, was the positioning of openings which create visual corridors into the neighbour's house. The separation of the sexes was highly regarded, and in the context of housing, the family and particularly the female members are the main concern in visual privacy. Accordingly, a building situation that facilitates visual overlooking is considered harmful, and is therefore an offence for the neighbour and must be avoided. Both Brunschvig and Hakim give extensive examples of complaints generated by the opening of a new door, which is not allowed if it faces directly the opposite neighbour's door (Hakim B., 1986, p. 39; Brunschvig R., 1947, pp. 138-139). Both writers relate the above building guidelines to the Islamic social and ethical requirements (i.e. the seclusion of women).

These spatial notions open up questions concerning the nature and type of spatial rules to be implemented in the model. Clearly, the main problem issues that generated conflicts centred around issues dealing with i- the right of usage of the exterior open space of a building; ii- the minimum right-of-way of streets and pathways in three-dimensional terms, (i.e., the minimum width to be allowed between buildings on either side of a street, minimum height); iii- the ownership and the usage rights of walls between neighbouring houses; iv- the positioning of the building on either sides of a street.

The questions that arise from these morphological issues are clearly related to

i- the type of spaces and the nature of their relationships, in the sense that the notion of a "fina" which is an exterior space always attached, by right, to a building, suggests two categories of spaces: one open -the "fina"- and one closed, the building. Once a space is designated as open (or a "fina" space), it cannot be built over or converted into a building.

ii- the quantity of open space (or the size of the "fina" space), which is not determined in relation to the size of the building.

iii- the building type. The significance of ownership and usage rights and privileges of walls between neighbouring houses is clearly an outcome of the organisational nature of the courtyard house type.

iv- the relations of buildings facing each other.

Clearly, most of the raised issues concerned only the building and the way in which it relates to its immediate setting (its "entourage"). That is to say, the control of building development may have been mainly centred at and linked with the local level of the town fabric.

However, it must be noted that there are some decisions which are taken at the level of the settlement as a whole. For example, the position and the construction of the town remparts or the location of the main mosque, the market or the burial grounds seem to be decided globally. These factors are mainly about the overall town structure as defined by the location of the main buildings and the distribution of land uses. This is not the main concern of this study which aims to focus on the urban fabric itself.

The analysis of the historical evidence suggests then that the concern with building development control, did not rely on prescriptive standards (*). The impact of such a process on the settlement form seems to be distinctly different from a mechanism based on numerical standards, as with contemporary zoning and planning regulations.

In the light of the information drawn from the historical material, some criteria and guidelines can be formulated for the identification and the definition of the rules and constraints to be implemented in the model. These can be summarized as follows:

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* The decisions concerning a problem, i.e. overlooking, are taken by the Qadi of the town with the collaboration of his master mason to carry out the orders and implement the solutions provided by the Qadi.

- The rules are of a local scope, defining the rights and obligations of immediate neighbours.

- Each building is attributed its own "fina", the exterior open space.

- Forbiddance of protrusion into the "fina" space.

- Buildings on either sides of the street are set back from each other in order to avoid the problem of overlooking.

- The adoption of the courtyard house type and the usage of the neighbours' walls between contiguous houses.

GENERAL FORMAL CHARACTERISTICS:

Before getting into the description of the model itself, it seems important to review and underline some of the physical characteristics that are prevailing in the settlements under study. This is so, because the aim of this chapter remains to generate systems with the descriptive characteristics as well as the numerical properties as observed in the real case studies.

The streets and alleys of the Mzab towns and Ghadames divide the urban fabric into distinct, bounded areas called islands or blocks. These vary considerably in shape and in size. For instance, in area, they range from 240 m2 to up approximately 5500 m2.

The general impression that may be gained by a casual examination of the ground plans of these settlements (see figures 2.3, 2.14, 2.17) is of an extremely dense morphology, composed chiefly of small buildings (their size varying between 60 m2 to 150 m2), haphazardly arranged. Historically, families of varied incomes lived next to each other. This integration of different income categories was reflected in the aggregation of houses of different sizes. The size of the dwelling units was related to income and social class; the rich family would have the largest house and the modest or poor family the smallest (i.e. Hakim B., 1986, p. 168). The dense packing of buildings is only occasionally punctuated by a few open squares. This intensive development of land is clearly demonstrated by the measurement of the percentage of land invested in the circulation system. In Beni Isguen, for example, the calculation of the area used by streets was carried out on the settlement within the second stage boundaries. The area used for streets and alleys is, in this case, only 0.85 ha (8525 m2) and the total land area is approximately 4.9 ha (49000 m2). This represents only 17% of the total land used for circulation which means a very high ground coverage of 83% (i.e. the built-up land area over the total land area). For Ghardaia, the ground coverage is about 84.5%.

The other general feature about these towns is that the vast majority of buildings, regardless of their location, have plans which tend to approach an orthogonal geometry (see Aerial Photographs in figures 2.2, 2.13 and 2.16). It is perhaps more precise to speak of distortions of rectangles and squares, since the contour lines of buildings show a great deal of deviation from the orthogonal geometry.

These general characteristics together with the spatial information derived from the historical material, form a useful basis for the design of the model. The main task of the model is then to try to generate systems with the following properties, in addition to the numerical properties as presented at the beginning of this chapter:

- an irregular street structure
- a small amount of space reserved for streets
- a very dense fabric with many cul-de-sacs
- variation in the size of the houses
- buildings based on orthogonal geometry

INTRODUCTORY NOTES TO THE MODEL:

The basic requirements for a model to address the questions outlined above are then:

i- the model should be based on a recursive procedure to simulate the incremental development.

ii- It should be based on simple local rules.

iii- It should be at least partly "non-deterministic" to allow for variation on the theme provided by the rules.

The most promising candidate for such requirements is the "syntax generative model" developed by Hillier and Hanson (Hillier B., Hanson J., 1984, pp. 56-60), designed to account for a particular spatial arrangement observed in a set of settlements in the region of Vaucluse in Southern France. This model has provided a general base for the study of a particular type of urban forms, referred to as "the deformed-grid" (Ibid, p. 56-60).

The "space syntax" model operates repeatedly on simple local rules that are applied on a random background, to the growing morphology. It defines two types of cells of the same size and shape; the closed cell, referred to as x cell, representing the building, attached on a full facewise to an open cell, referred to as y cell, which is the means by which access is gained to the closed cell. The introduction of the notion of an open cell is of fundamental importance for a model which seeks to follow simple local rules for its operations. For example, the initial model developed by Coates, "the court model", had only one cell type, and this has required a global rule for accessibility (Coates P., 1983, pp. 40-42). By defining two cell types that are automatically attached to each other, a local link has then been established between the accessibility rule and the building, since both can be expressed in terms of x-y relations. These pair cells are then aggregated, always by joining the open cell onto at least another open cell, but randomising the location of the closed cells, and not allowing vertex joining of these latter.

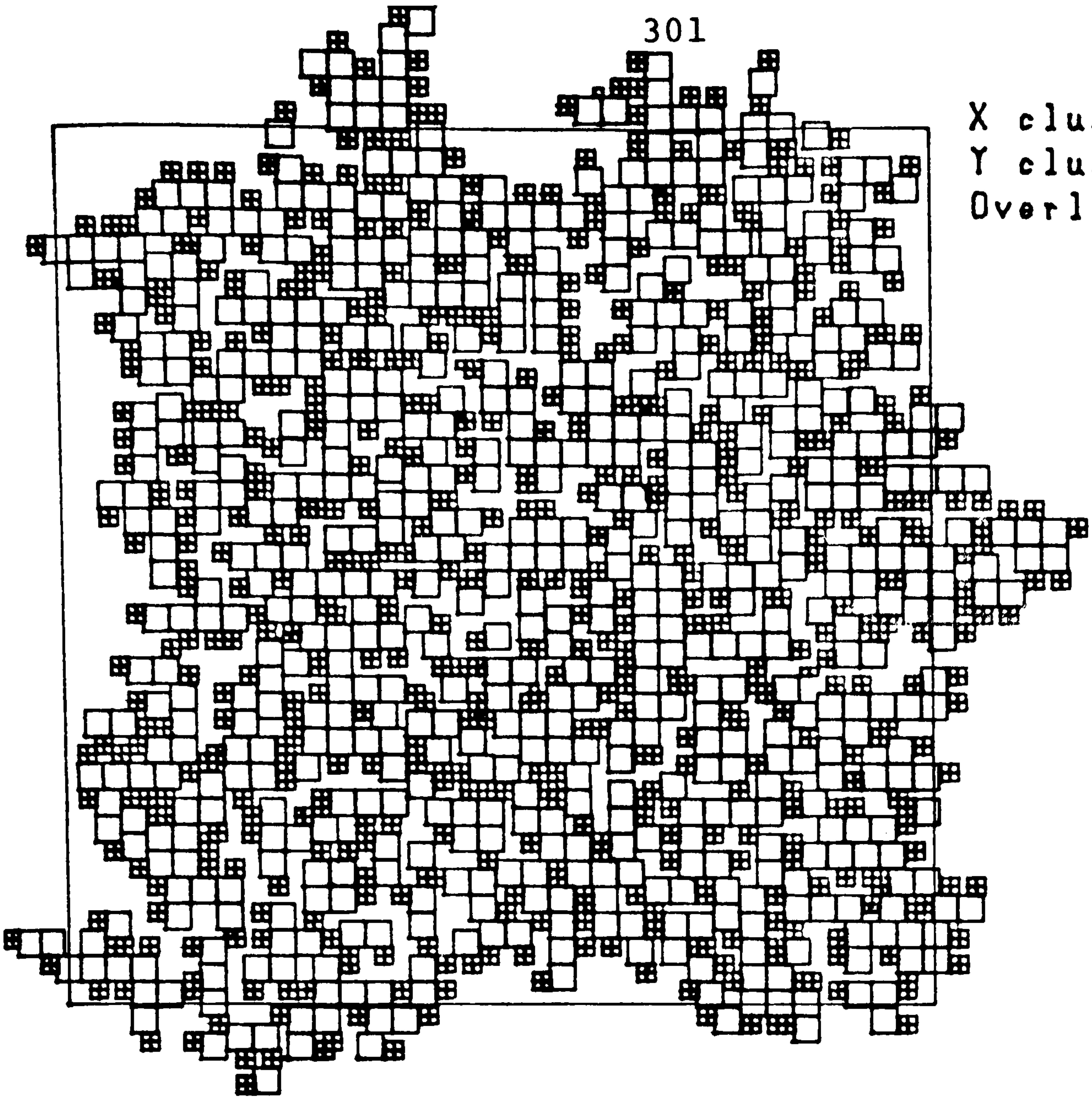
The resulting pattern of the aggregated open cells presented distinctive properties. These define continuous rings of open space, marked by frequent variations in width. This spatial arrangement exhibited strong resemblance to the configurations observed in the French villages. It is what Hillier and Hanson call "the beady ring structure" (Hillier B., Hanson J., 1984, pp. 56-60).

PRESENTATION OF THE MODEL:

The following model is an adaptation of the "syntax model", although it is designed to account for completely different morphological and spatial characteristics. It draws heavily on the ideas developed in the generative syntax section of the "Social logic of space" (Ibid, pp. 52-60), and also on the research project undertaken by Coates (Coates P., 1983).

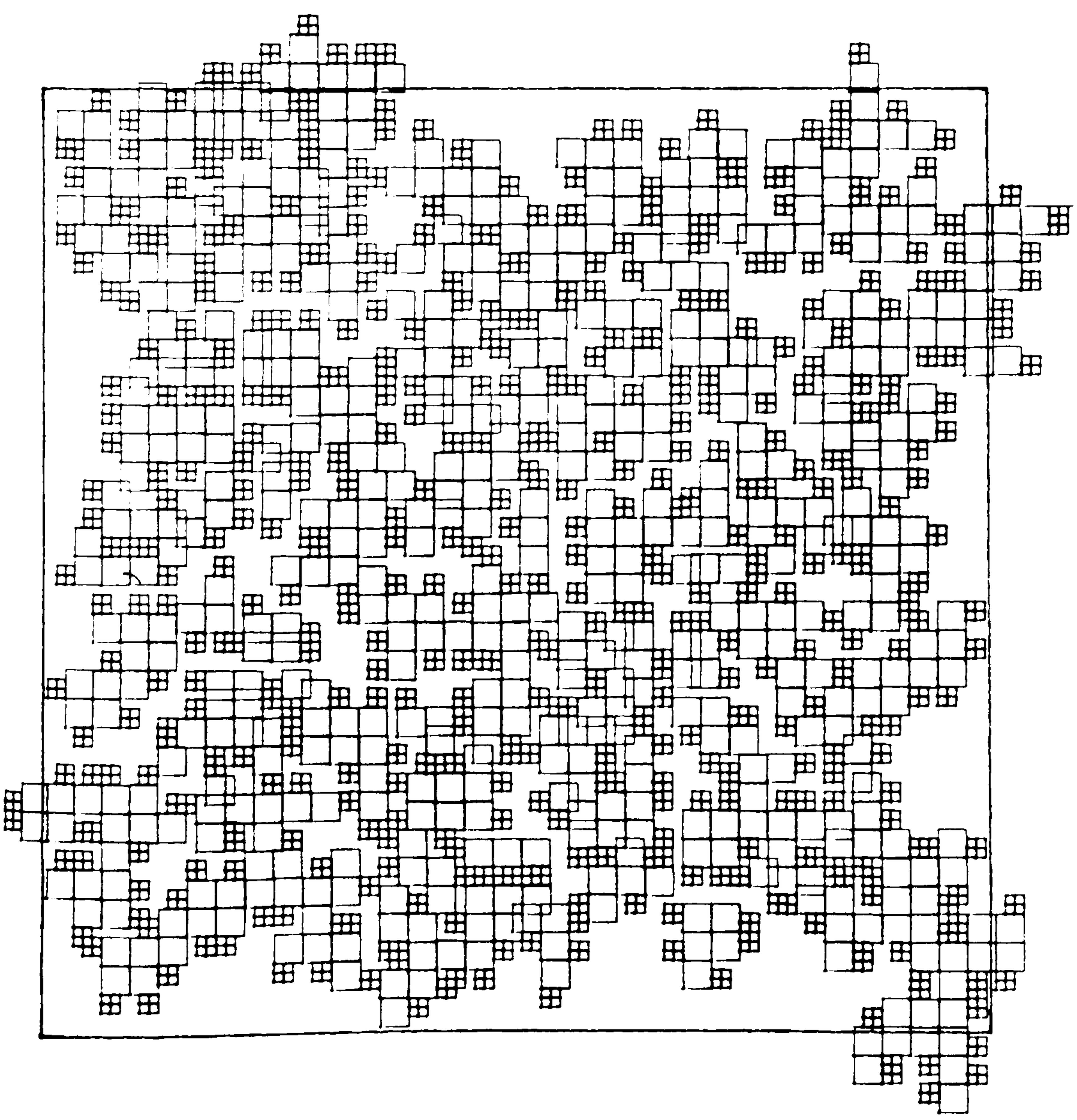
Similarly to the syntax model, the present model is a cell-growth type which uses basically two types of cells, the x cell representing the building and the y cell, the adjacent segment of the street, representing the threshold of the building. In addition to these two cell types, a further two cell types exist, the "unallocated cell" which constitutes the unallocated space; and the "backwall" cell. A description of each type is presented in the following.

- The x cell is a 3x3 unit block, while the y cell is a 1x3 unit block, so that a full facewise joining between x and y cell is made possible. The difference in size between the x and y cells is a departure from the syntax model in which the two cell types are of the same size. This difference was introduced as a means to account for the "narrowness" of the streets and the limited amount of land used for circulation as observed in the towns under consideration. Initially, the y cell was defined as a 2x2 block. The reason behind this amendment is that the main feature which consistently fails to emerge from the generated morphologies is the formation of complete rings that do not include too much of the "unallocated" space. In figures 5.1 and 5.2 are examples of these morphologies which are characterized with some rings and many cul-de-sacs; but the large blocks of x cells remain elusive, with the y structure broken up into isolated segments. The rules used to generate these morphologies are not different from the rules applied in the final form of the model. These will be presented in the ensuing sections.



X clustering 0.80
Y clustering 0.60
Overlap allowed 0.00

X CELL OR CLOSED
Y CELL OR OPEN



X CLUSTERING 0.60
Y CLUSTERING 0.00
OVERLAP ALLOWED 5.00

FIGURES 5.1, 5.2 : EXAMPLES OF GENERATED MORPHOLOGIES BEFORE AMENDMENTS.

The <u>backwall cell</u>: is a 1x3 unit block which is attached to the x cells, always on the opposite side to which the y cell is attached, as illustrated by the diagram.

This is designed as a measure to prevent an x cell having two y cells on two opposite sides. A backwall cell once allocated can only be overwritten by an x cell.

The <u>unallocated cell</u> consists of all "unused" cells that are not defined as x, y or backwall cells. There is no restriction on this type of cell becoming a cell of another type.

THE GENERATIVE PARAMETERS:

The generative model operates only on the basis of local rules, applied on a random background. The meaning of the rule being local is that only the conditions immediately surrounding a new cell are considered when deciding whether to add the new cell to the system. The model depends on four parameters. These are:

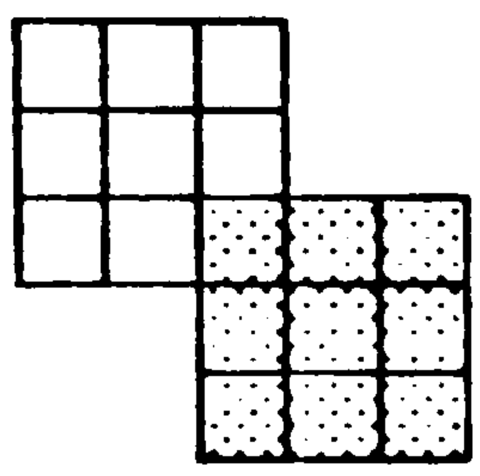
- The <u>x clustering</u> which varies between 0 and 1. An x clustering of 1 ensures that the morphology will grow always by joining the closed cell onto at least another closed cell; whilst an x clustering of 0 ensures a random allocation of x cells, that is there is no restriction on x cells to join onto another x cell.

- The y joining parameter which also varies between 0 and 1. Similarly to the x clustering, a y joining of 1 will ensure that the morphology will grow always by joining the open cells onto at least another open cell. Conversely, a y joining of 0 ensures a random location of the open cells with respect to the other open cells already placed.

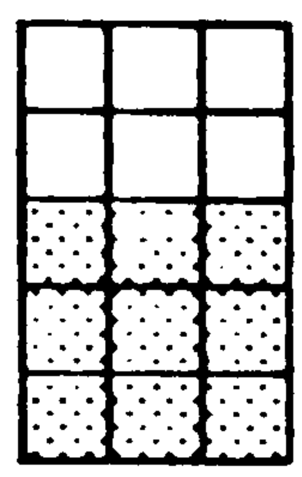
The variations of the joining probabilities of x clustering and y joining parameters have been syntactically explored by Coates, using only 0 and 1 probabilities, and in which he has concluded that the ring formation is mainly determined by the joining rule and the continuity in the aggregation of either type of cells is created by the clustering rule (Coates P., 1983, pp. 57-60).

According to the value given to the parameters, the mode of allocation can therefore be either x-led or y-led, in the sense that an x-led mode will operate by attaching first the closed cell to an existing x cell when adding new elements to the growing morphology, and then place its y cell. Conversely, a y-led mode operates by adding first a y cell to an existing y cell and then places randomly its attendant x cell.

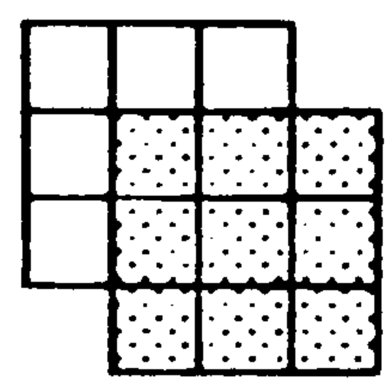
- The x overlap parameter which determines the amount of an existing x cell a new one is allowed to overwrite. This parameter varies between 0 and 9. An overlap of 0 ensures that all x cells are square (3x3 unit blocks); with an overlap greater than 0, x cells can be rectangular, L-shaped etc... (see diagrams below). In fact, the relation between the numerical value of the overlap and the resulting shape of the x cell is random. This parameter is introduced in order to allow for a variation of sizes of x cells as was often found to be the case in the towns under study.



OVERLAP = 1

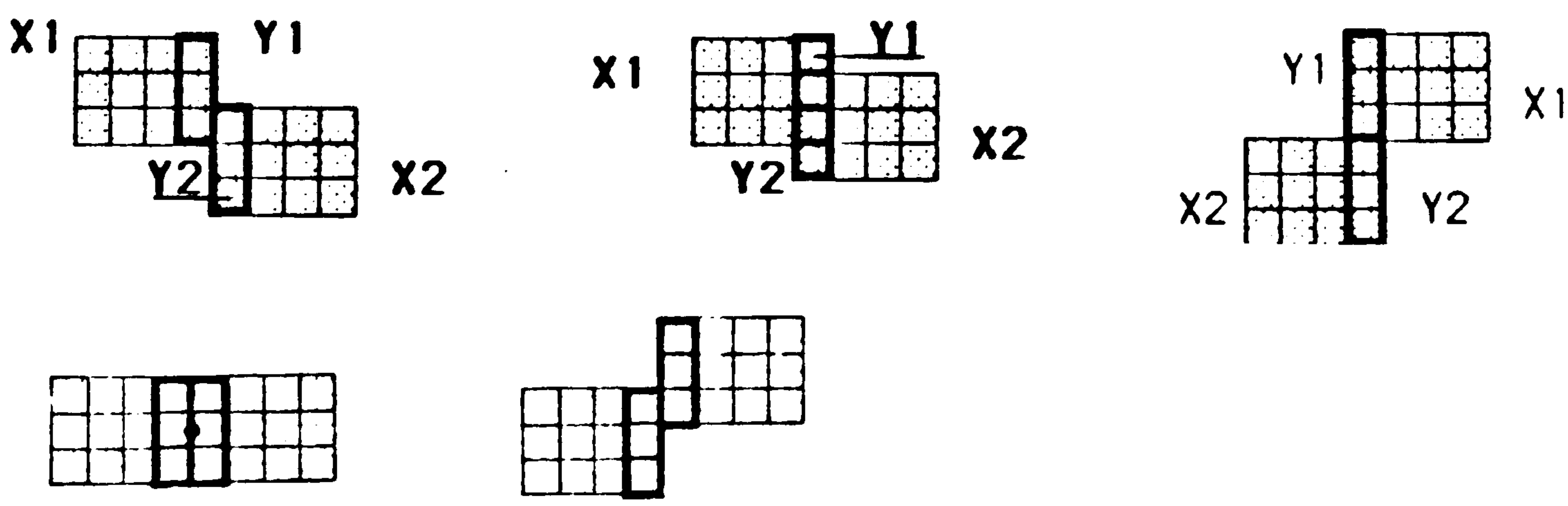


OVERLAP = 3



OVERLAP = 4

- The y sliding parameter which determines the way in which a new y cell is positioned when joining onto an existing y cell. It varies between 0 and 1. A y sliding of 0 ensures a random y to y cell joining such as illustrated by the following diagrams.



While a y sliding of 1 ensures that y cells join such that the outcome "string" of y cells is always longer than the single y cell, as shown by the diagrams; but the actual amount of sliding is randomized. This parameter has a sort of a "globalizing rule effect", in the sense that it biasses the allocation of y cells in such a way that they prefer to extend linearly rather than form clumps.

The mode of cell allocation is then determined on the basis of the joining probability values assigned to the different parameters and compared against a random number provided by the computer. If there are various possibilities satisfying the rules and constraints, the location is then again randomly selected.

In addition to these parameters, the size of the morphology constitutes another varying parameter. It is in fact the size of the frame which defines the site for the growing morphology. The relevance of the size of the "frame" means that no new "seed" (or cell) is to be placed outside the specified site, during the generation of the morphology. But the morphology can still grow outside the frame boundaries until the list of coordinates is full (1000 cells). In this case, the morphology will continue to grow but only by attaching the new cells to the existing ones, x or y as specified by the set of joining probabilities in the input data.

The model was first explored manually, using a lego board and "modulex" elements of different sizes and of two colours to distinguish between the two cell types. These manual experiments constituted a major feed-back in defining the rules and in the writing of the algorithm shown in the flow chart in figure 5.3, which

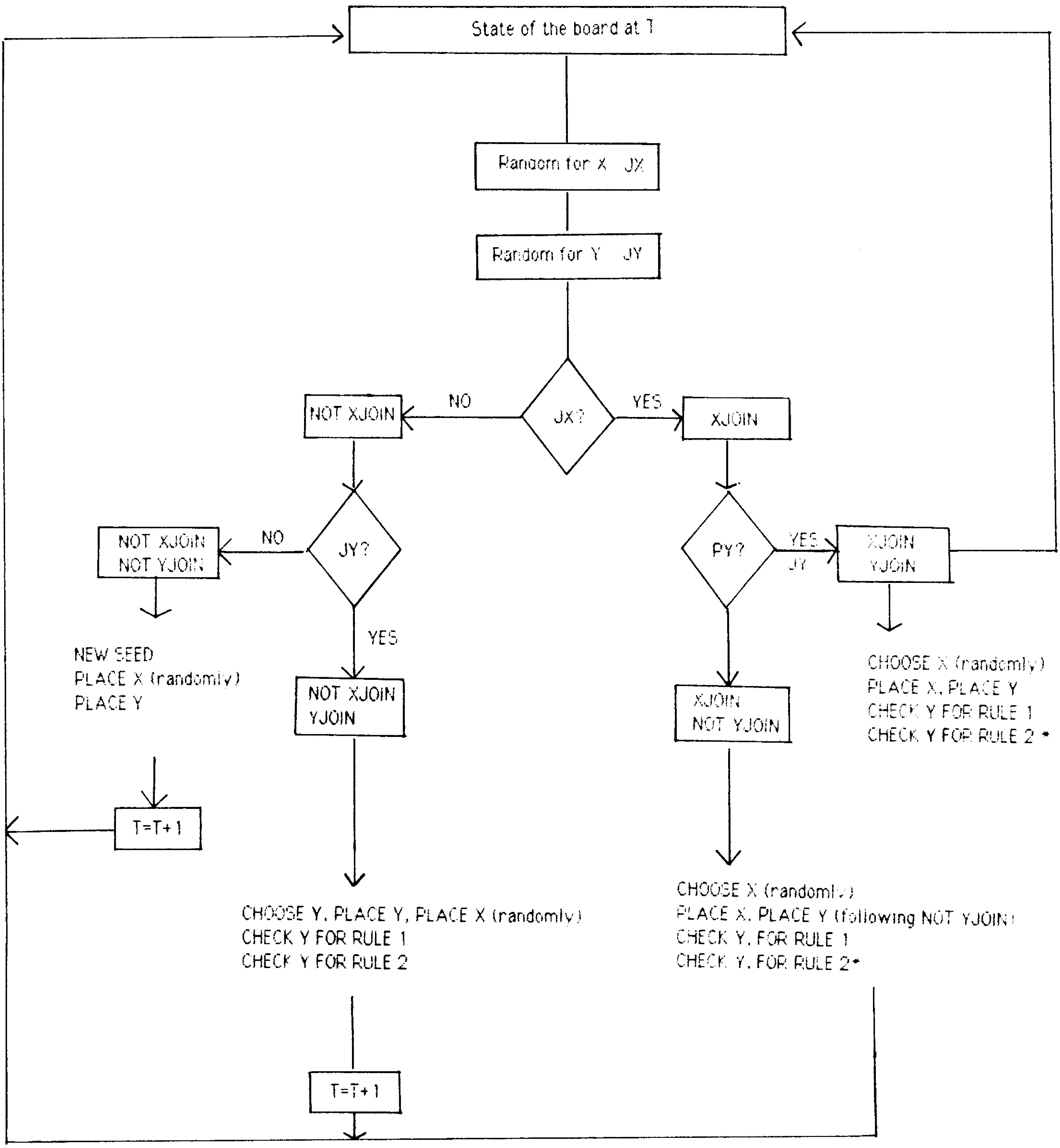


FIG. 5.3 : FLOW CHART

RULE 1 : No y cell should be attached to x's on more than 3 sides.

RULE 2 : No y cell should be attached to an existing x that has already a y on the opposite side.

summarizes the rules of allocation, and which has been used to implement the model on the computer. The process is quite simple. It begins by placing an x cell and its attendant y cell, randomly on the board, and aggregates similar cell pairs, following the rules specified by the syntax and the joining probabilities given to the parameters. This process appears to generate a morphology with large blocks, many cul-de-sacs and narrow and irregular structure of the open cells. Figure 5.4 shows examples of morphologies generated manually, in which the y cells tend to form narrow but consistent pathways through the system, and define large blocks of x cells penetrated by some cul-de-sacs. When the exercise is repeated by insisting on x joining, the outcome pattern of the y cells becomes more fragmented and constituted by a series of isolated segments of y cells. This seems to generate morphologies with some rings and many cul-de-sacs with the blocks becoming much larger.

RULES FOR CELL ALLOCATION:

For the computer model, the rules for cell allocation were set up as follows:

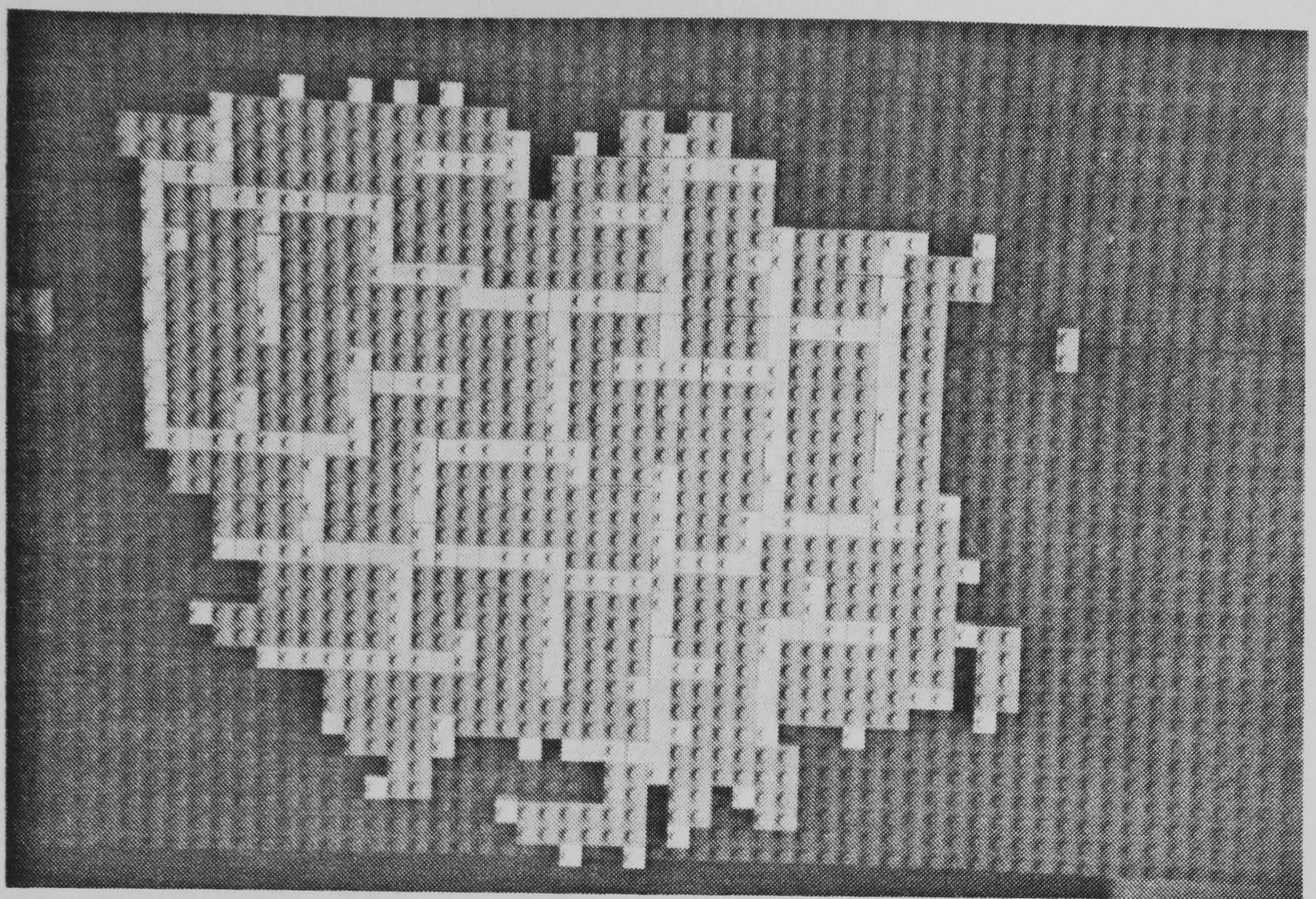


FIG. 5.4: PICTURE OF MORPHOLOGIES GENERATED MANUALLY.

a- X CELL ALLOCATION:

1. A new x cell may overlap an existing x by as much as is given in the overlap parameter.

2. No x cell should have a y cell on two opposite sides of itself.

3. No x cell may overlap a y cell.

4. No x cell should be only joined to another x cell by a vertex.

5. No new x cell can be placed unless it is also possible to place its attendant y cell.

b- Y CELL ALLOCATION:

1. A new y cell may overlap an existing y cell by as much amount as is allowed by the sliding parameter.

2. No y cell may overwrite an existing x cell.

3. No y cell may have more than three sides fully adjacent to x cells. This is to avoid having open cell fully surrounded by closed cells.

4. No y cell may be placed next to an x cell such that it violates rule (2) in the allocation of x cells.

5. No y cell can be placed unless it is also possible to place its attendant x cell.

Each x cell has 4 possible sites for a y cell next to it, and each y cell has also 4. At the start of an attempt of allocation next to an existing cell, these 4 positions are "shuffled" and then worked through in order. If after this exhaustive but random search the allocation fails, then the whole attempt must be abandoned.

PROGRAM DESCRIPTION:

The program is written in BBC Basic and implemented on a BBC B series micro-computer with a 6502 second processor (*). The video memory is used to display the evolving morphology and as the data for all operations requiring spatial information about the relationships between the cells.

The computer model is a cellular automaton with the array of available cells being provided by the "pixel map" (*) of the screen memory. It was decided to restrict this array to a square of side n, such as 0> n >250, with the actual size for a given run input as a value in this range. In addition to the "pixel map",

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* The software has been prepared by P. Coates, who without his contributions, this part of the research would have not been possible.

* The screen of the computer is divided up "dots or bits", each of which is called a "pixel" and the entire pattern is called "pixel map", which is then a "dot representation" of the screen. Any figure to be drawn on the screen is a multiple of pixels. For example, an x cell is a block of 3x3 pixels.

two lists of x and y cell coordinate pairs are maintained and stored in the computer memory, for fast access when searching for an x or a y cell to join to the new element. The computer memory limitations restrict these lists to 1000 coordinates, giving therefore an optimum size of the square of the growing morphology in the range of $100>n>150$ in order to achieve a dense pattern with 1000 cells.

The principle of a cellular automaton is that, starting from a known state T, a set of cell allocations is made following the rules specified by the syntax and the joining probabilities; the counter is then increased to T+1. Given the state at T+1, new allocations are made, and so on until some arbitrary state Tn is reached. This is represented in the program by a single loop. Each pass through the loop generates two random numbers, using the Basic's Function RND.

If the initial parameters for joining are Px and Py then at any state T, Jx and Jy are the two random numbers to be compared with Px and Py in order to decide on the mode of allocation. For detailed description about the workings of the program the reader is referred to Appendix 1 of this report.

INPUT DATA:

The data input consists of giving values to five parameters:

i- x clustering parameter

ii- y joining parameter

iii- x overlap

iv- y sliding parameter

v- the size of the frame for the growing morphology.

OUTPUT DATA:

The program results are two-dimensional plans which are stored on the screen, and optionally on a A3 format 6 pen plotter. At the end of a run, the screen memory can be stored in a disc for later viewing.

A casual examination of the simulated morphologies as illustrated by the following figures, shows certain resemblance with the real examples. especially in terms of density and the degree of grid deformation of the y structure. These results appear quite promising to undertake the next stage of the research which aims mainly at the assessment of these computer generated systems and their comparison to the towns under consideration.

LIMITATIONS OF THE MODEL:

This model is severely limited in its power to fully reproduce the real examples by its cellular nature. It is possible that some features of the model are not effects of the rules and the process, but may be artefacts of the rigid geometrical constraints imposed by the cellular system. But, in the geometry-free morphological model developed by Coates, it was also possible to observe the effects of determining other allocation geometries apart from the orthogonal one used in a cellular system (Coates P., 1983, pp. 64-69).

PRESENTATION AND DESCRIPTION OF THE GENERATED SYSTEMS:

Many runs of the final program have been produced by testing the effect of varying the parameters on the growing morphologies. These systems are inserted at the end of this report in Appendix 2.

The procedure adopted in the simulation has been as follows:

i- to generate morphologies by varying the x clustering (Px) at intervals of 0.2 from a random (Px=0) towards a determinate situation (Px=1), while randomizing the location of y cells, and keeping the y sliding constant.

ii- to generate morphologies by varying the y joining parameter (Py) at intervals of 0.2 from a random to a definite situation (Py=1), while keeping the allocation of closed cells random and the y sliding constant.

iii- to generate morphologies by varying one of the two parameters (Px or Py) and keeping the other constant but set to a value greater than zero, and also keeping the y sliding constant.

iv- to generate morphologies by varying the y sliding parameter (Ps) at intervals of 0.2, from a random towards a finite situation, and keeping the x clustering and y joining constant.

In all cases, the overlap was set to 5, in order to allow for a mixture of different building sizes. Examples have been generated by varying this parameter (see Appendix 2), which does not seem to have great effect on the outcome morphologies. This remains a conjecture which has not been tested analytically. However, the introduction of the overlap was only an attempt to reconstruct one of the many characteristics of the urban surface, which is in reality constituted by buildings of various sizes. This parameter is merely a "given" factor rather than a rule capable of articulation; because in the model, the overlap is checked for only after the decision of joining the closed cells is taken.

For the purpose of the presentation and the preliminary description of the computer generated systems, these have been grouped into three main sets.

<u>Set One</u> includes the morphologies in which the closed cells allocation varies from a randomized to a determinate situation; that is x clustering takes the values

of 0, 0.4, 0.6, 0.8, 1.

Set Two includes the morphologies generated by varying the y joining parameter from 0, 0.2, 0.6, 0.7, 0.8, 1.

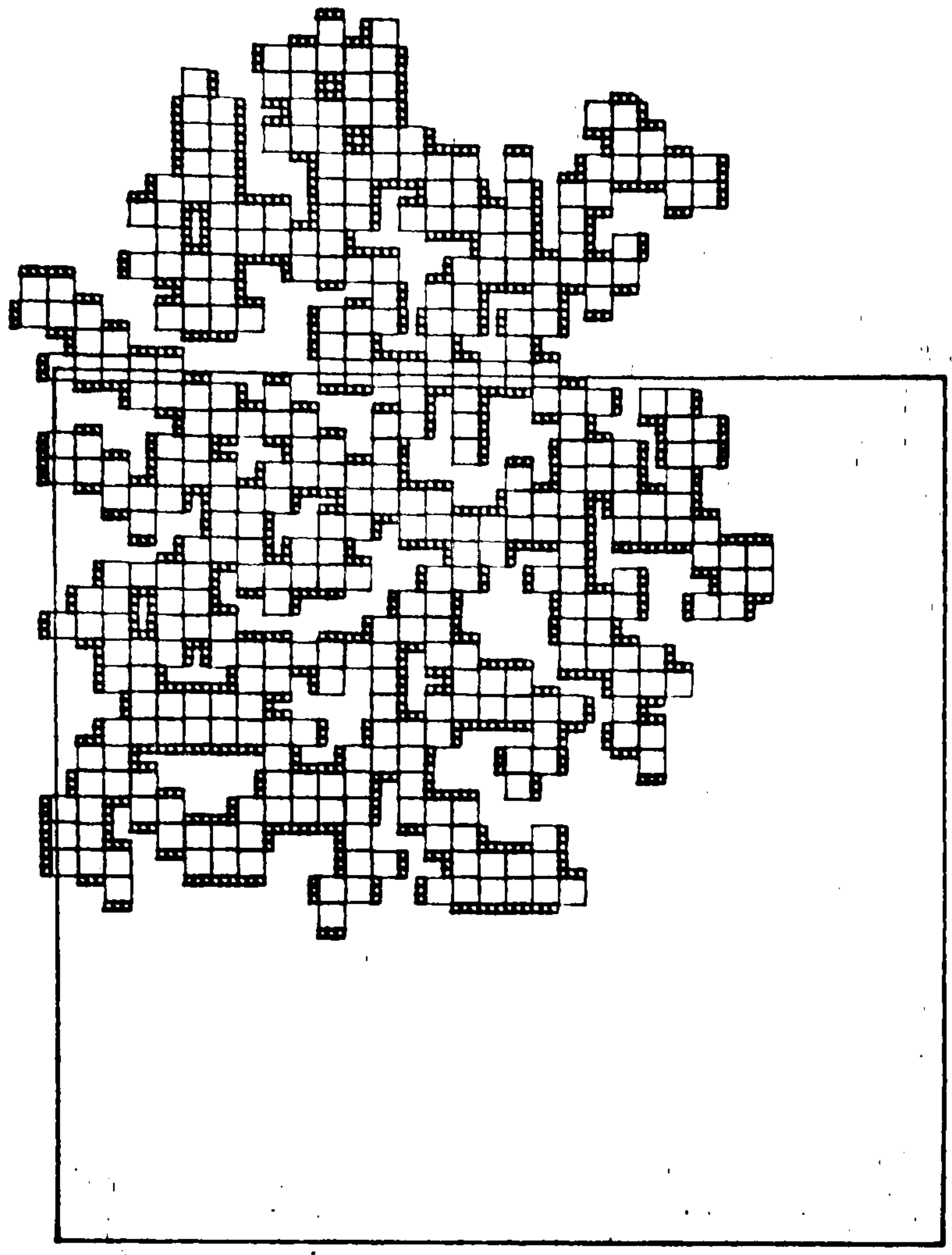
Set Three comprises morphologies generated by varying one of the two parameters (Px or Py) while the other is set constant at a value greater than zero; i.e. $0<Px<1$ with Py=0.6 or $0<Py<1$ with Px=0.4.

The general impression that may be obtained from a casual examination of the generated systems in figures 5.5 to 5.9, is that they present a dense packing of cells without any apparent distinctive global structure. The cross examination of the systems generated "randomly", that is the x clustering and y joining parameters are set to 0 (overlap=5; y sliding=0.8) and those generated by a gradual increase of the probabilities value for x clustering, and keeping the location of the y cells random (Px=0.2; Px=0.4; Px=0.6; Px=o.8; Px=1; with Py=0 for all cases) shows that the x clustering rule seems to produce morphologies with:

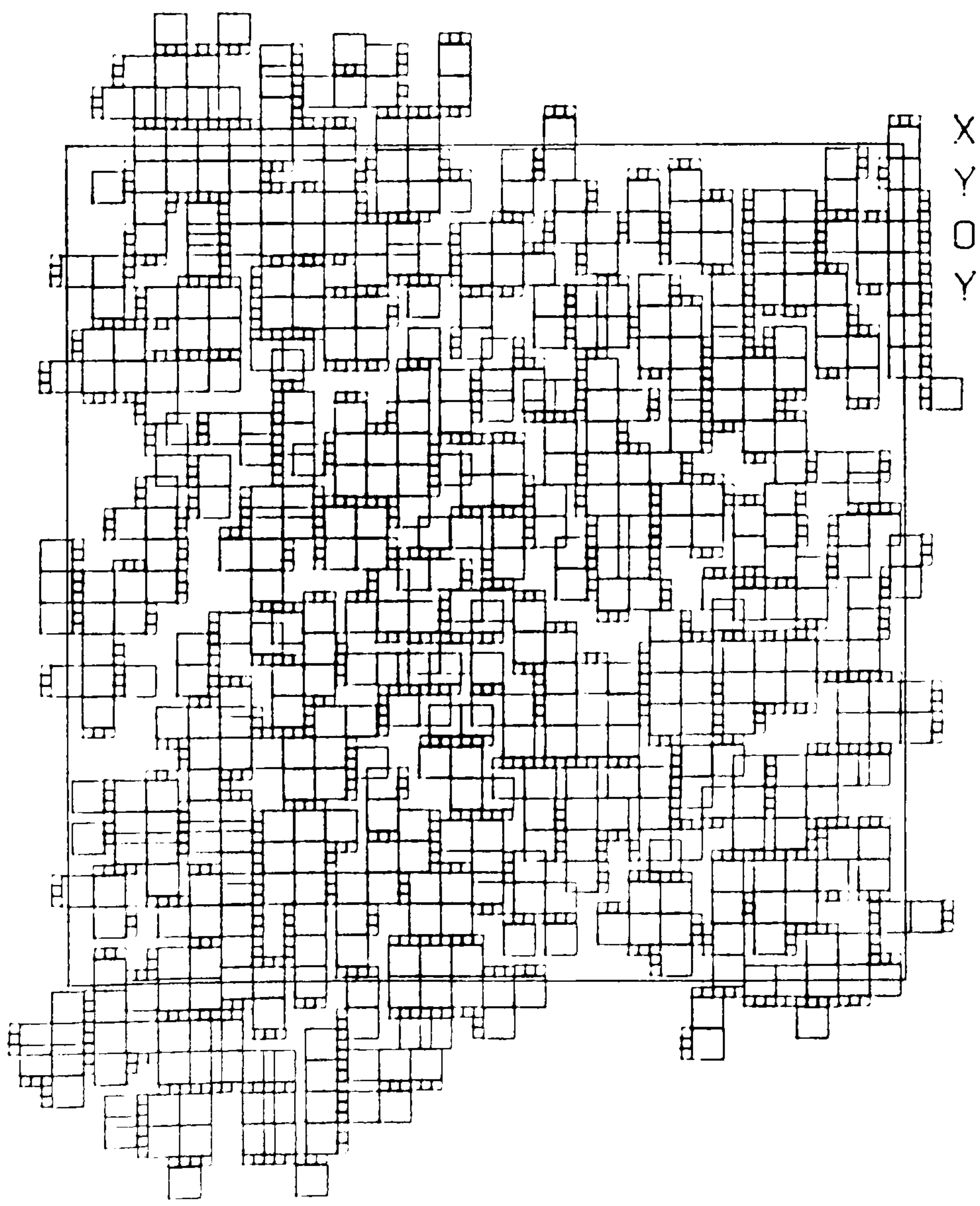
- larger blocks of x cells (the size of blocks refers to the number of x cells that are grouped together).

- more fragmented structure of y cells which tend to form more "clumps" of open cells (see fig. 5.5, 5.6).

In the extreme case of x clustering set to 1, the program will always generate morphologies which present a



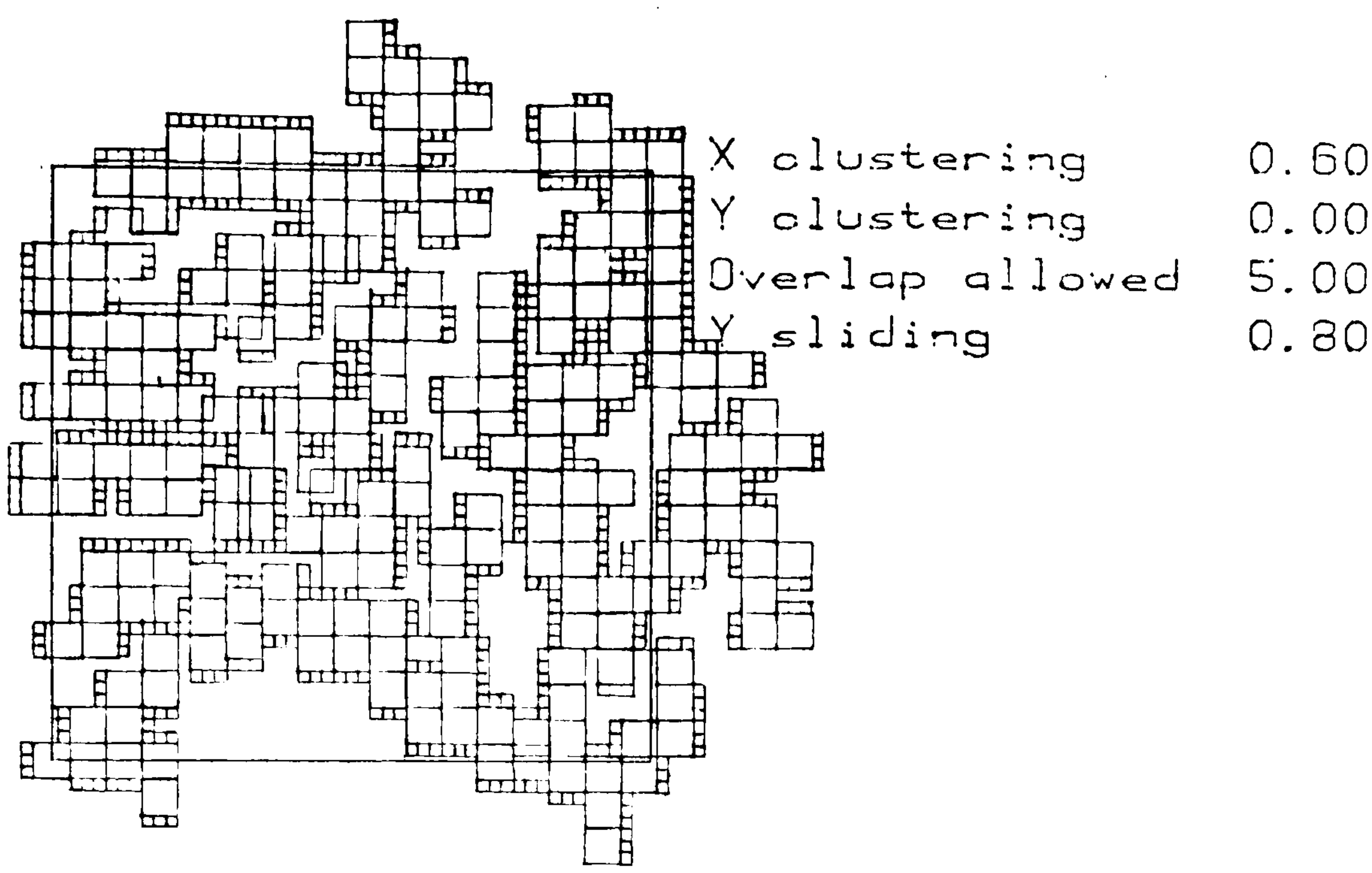
X clustering 1.00
Y clustering 0.00
Overlap allowed 5.00
Y sliding 0.80



X clustering 0.80
Y clustering 0.00
Overlap allowed 5.00
Y sliding 0.80

FIG. 5.5: EXAMPLES OF GENERATED MORPHOLOGIES BY VARYING X CLUSTERING, Y RANDOM.

X CELL OR CLOSED □
Y CELL OR OPEN



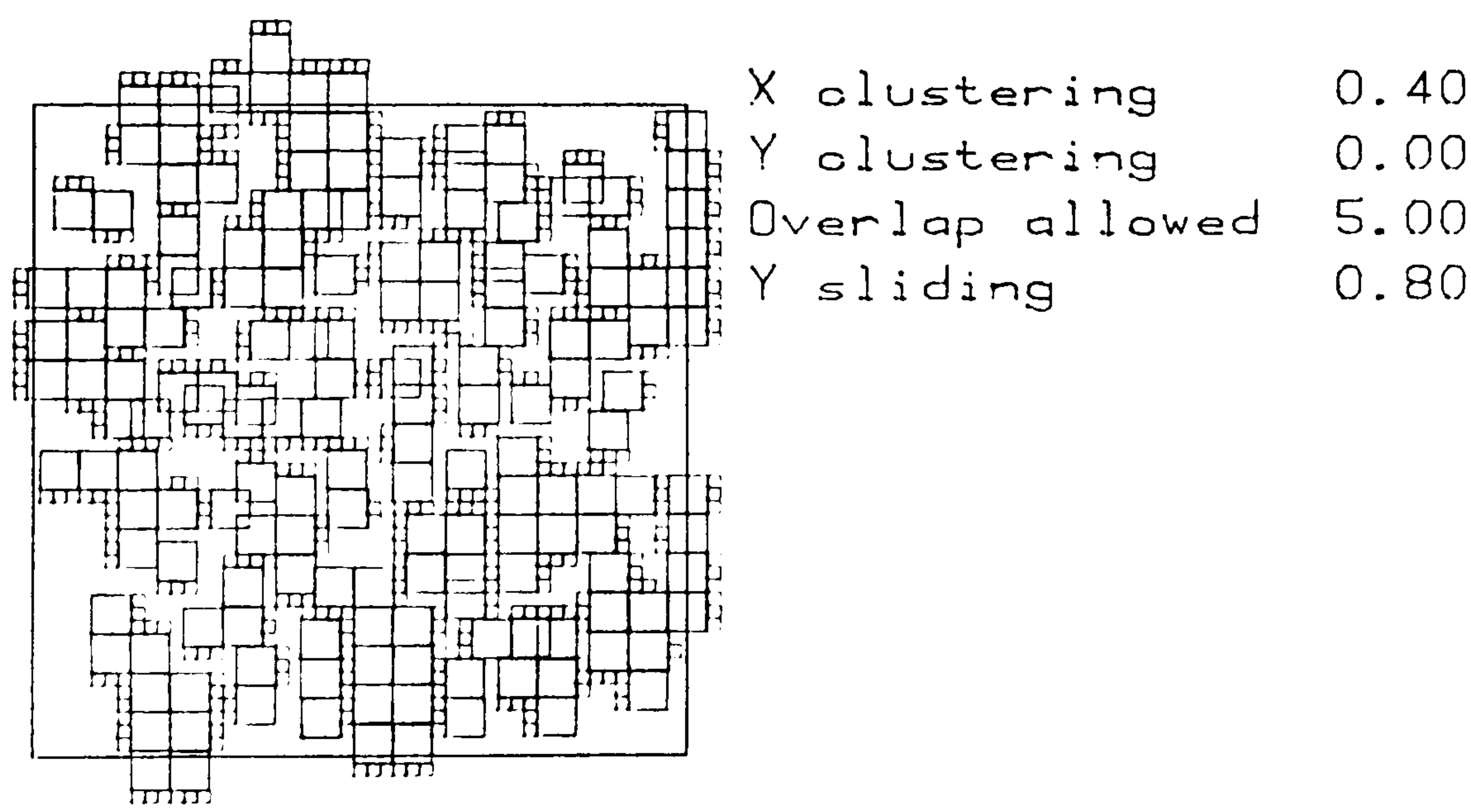


FIG. 5.6: EXAMPLES OF GENERATED MORPHOLOGIES BY VARYING X CLUSTERING, Y RANDOM.

X CELL OR CLOSED □

Y CELL OR OPEN ⊟

continuous surface of closed cells, perforated by enclosed "courts" of open and unallocated space.

On the other hand, the examination of the systems generated by increasing the probabilities value assigned to y joining parameter (see figures 5.7, 5.8, Py=0; Py=0.2; Py=0.4; Py=0.6; Py=0.8; Py=1; with Px=0 for all cases), shows that this rule seems to produce rather "rigid" morphologies with a more linear extension of the y cells, which form narrow and straight lines indiscriminately spread over the surface of the morphology. It also produces more elongated blocks of x cells. In the extreme case of y joining set to 1, the program produces a central string of y cells reminiscent of a street-terrace structure with a linear arrangement of closed cells on both sides of it.

Finally, the joint effect of the two rules, x clustering and y joining (i.e., Px=0.4 and Py=0.6 or Px=0.6 and Py=0.6, as shown in figures 5.9, 5.10) seems to create dense fabric with relatively smaller blocks of x cells and with the y cells forming more rings and many cul-de-sacs. The definition of the ring is strictly confined to a continuous circuit of actual y cells with fewer unallocated cells.

Figure 5.11 shows three examples of systems generated at 3 different sizes of the square and following the set of values: Px=0.4; Py=0.6; Overlap=5; Sy=0.8; with the resulting y structure blackened to facilitate the reading of the drawing. The difference in the size of

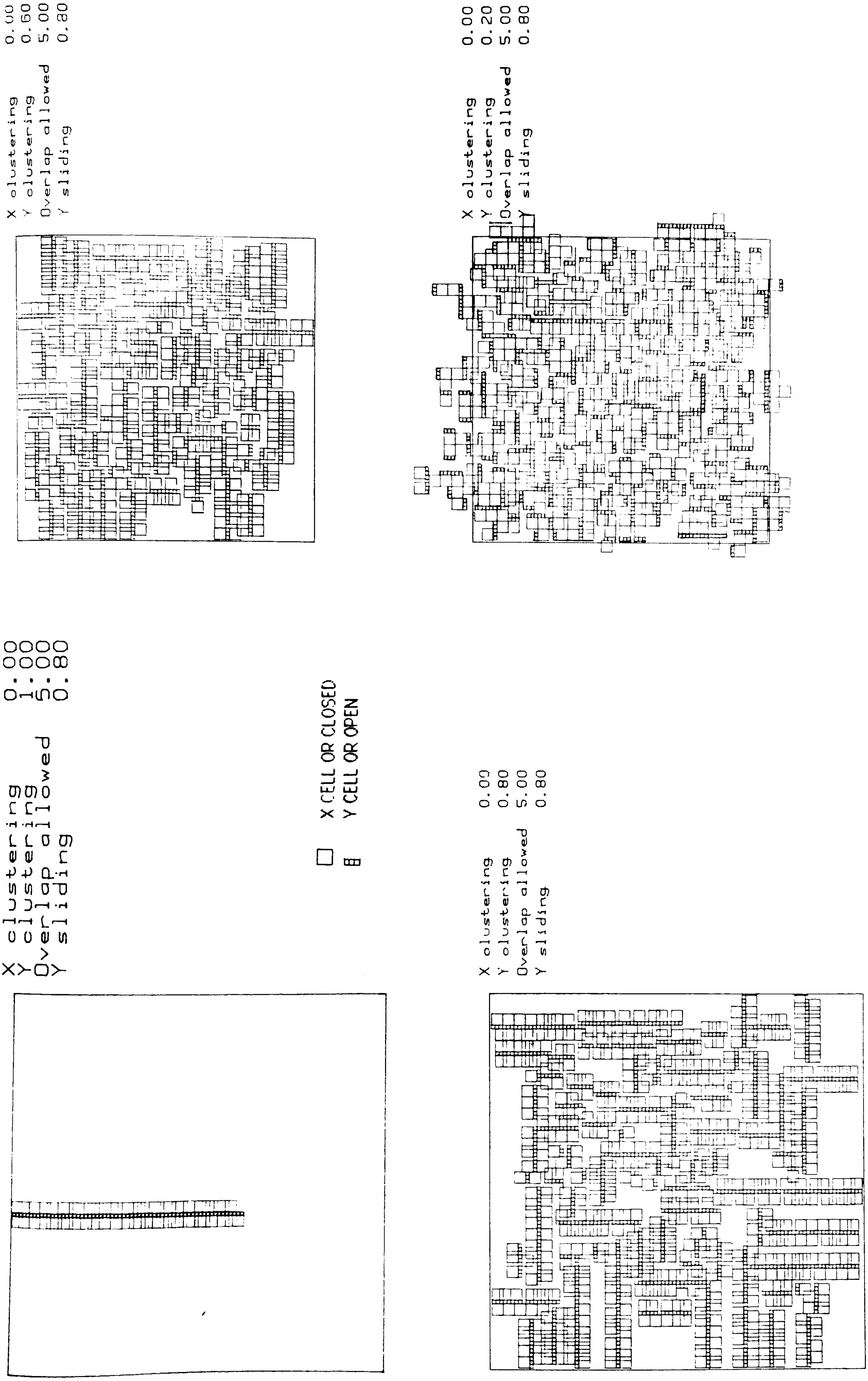
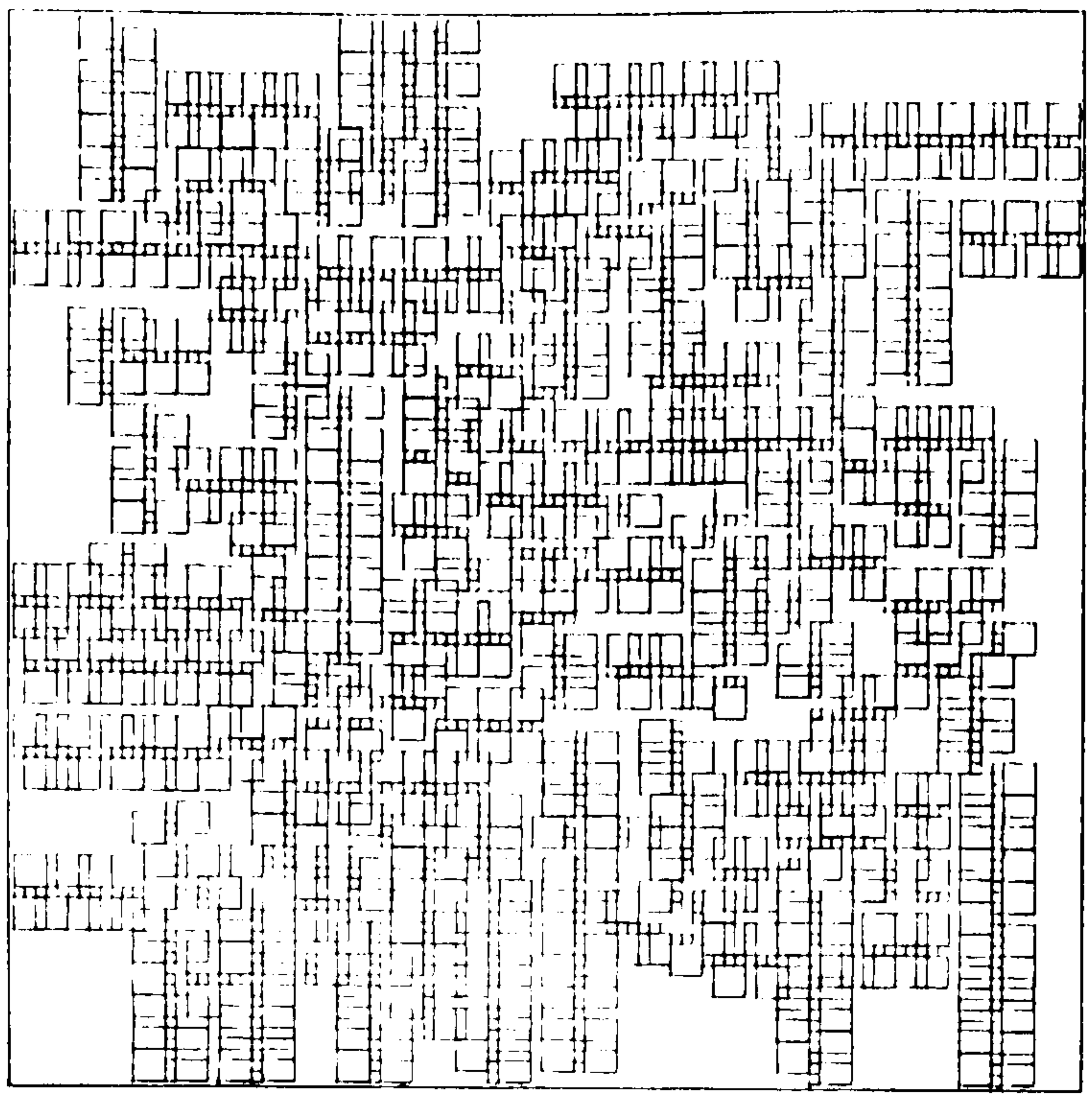
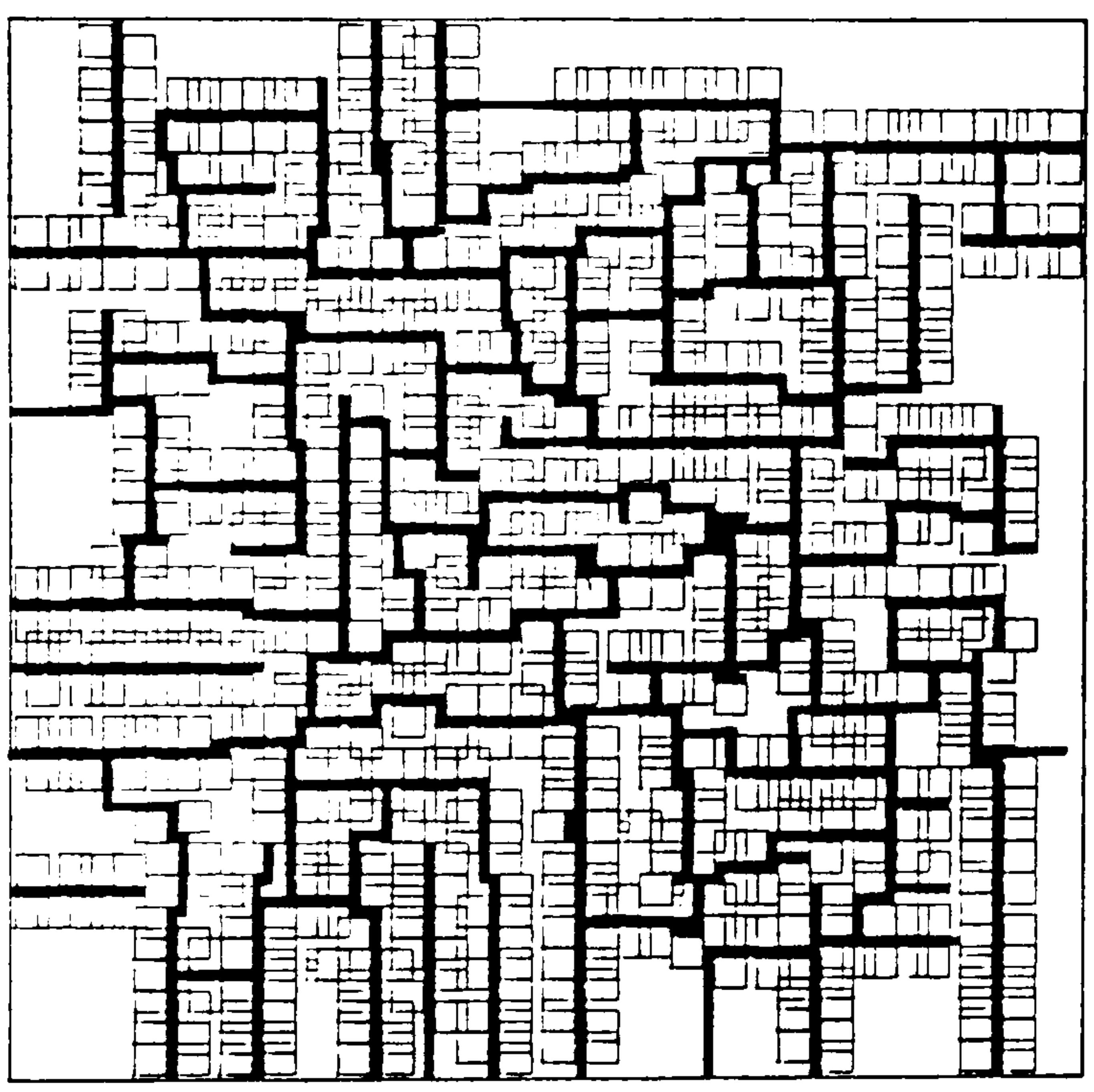


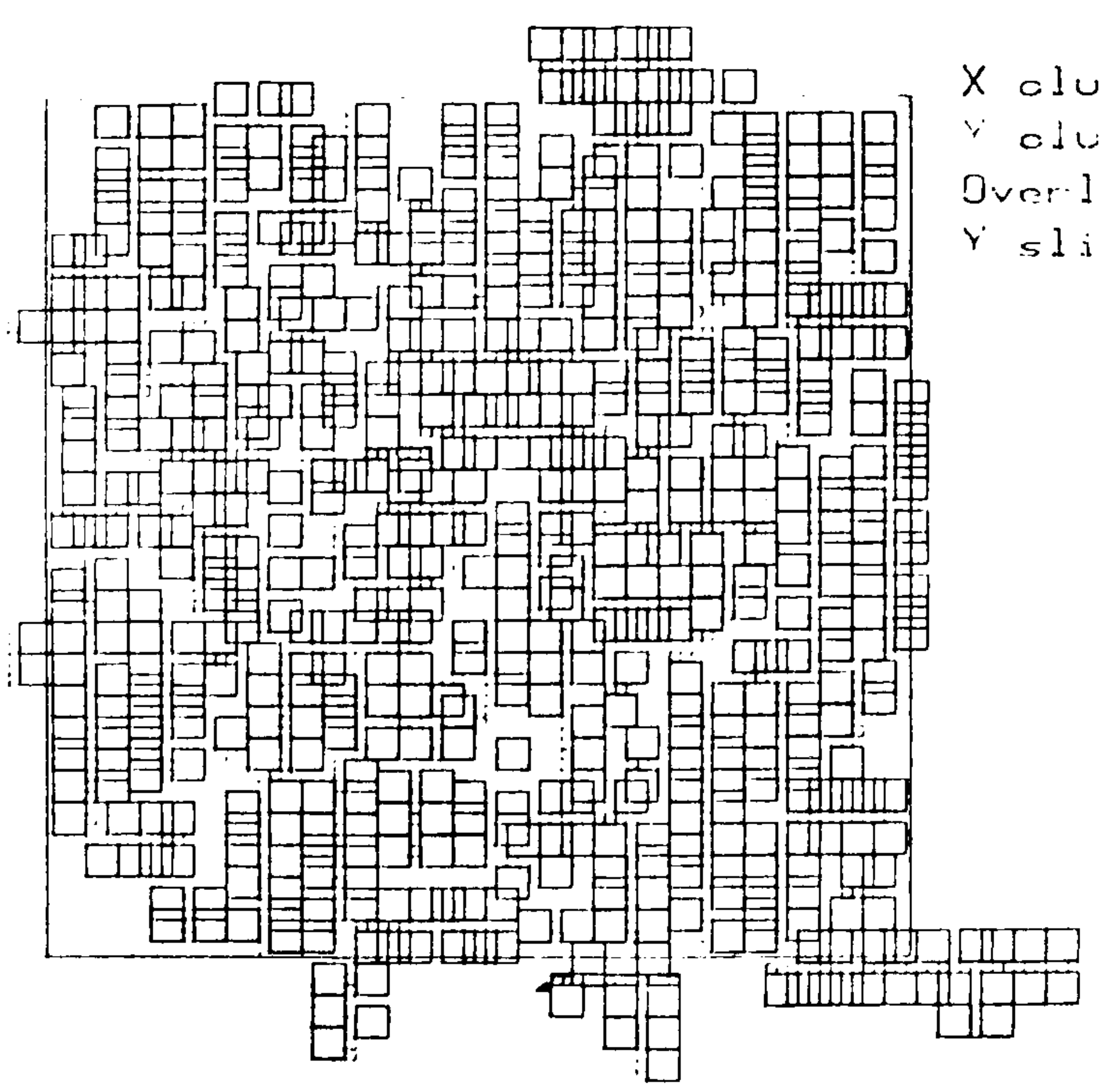
FIG. 5.7 : EXAMPLES OF GENERATED MORPHOLOGIES
BY VARYING Y JOINING, X RANDOM.
(These are reduced versions of the original copies).



X clustering 0.00
Y clustering 0.60
Overlap alloweed 5.00
Y sliding 0.80



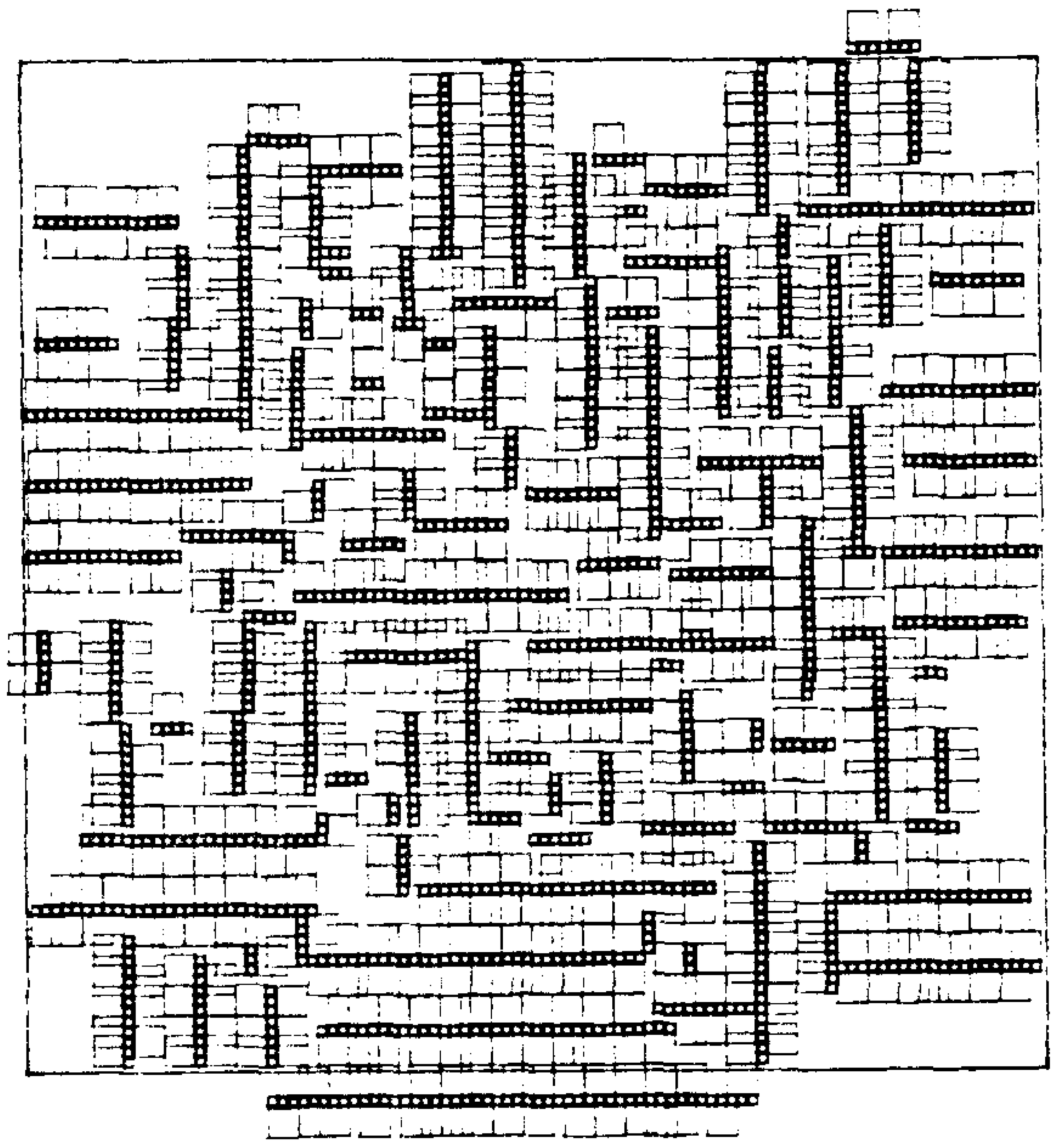
X clustering 0.00
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.80



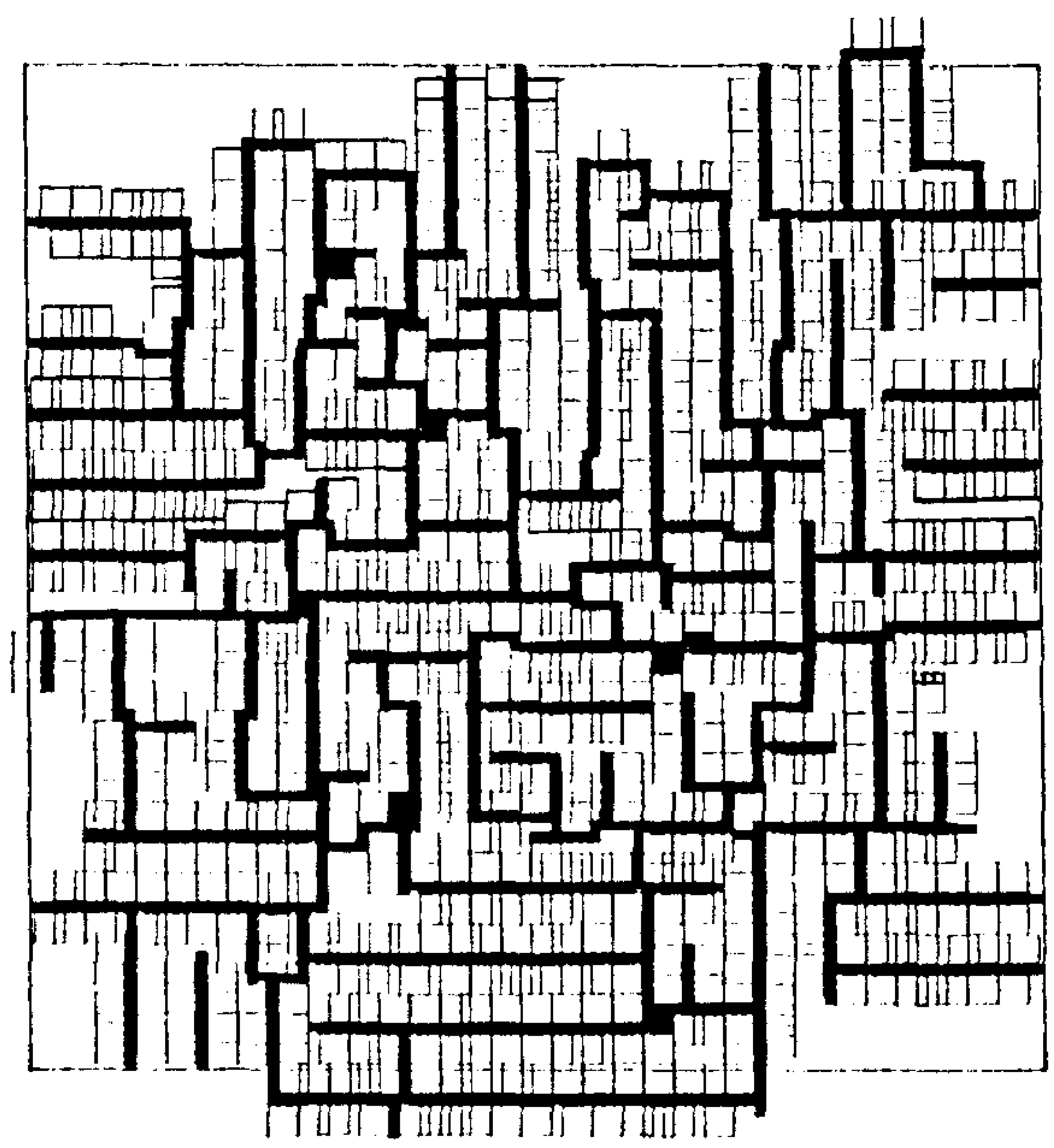
X clustering 0.40
Y clustering 0.70
Overlap allowed 5.00
Y sliding 0.80

FIG. 5.8 : EXAMPLES OF GENERATED MORPHOLOGIES
(These are reduced versions of the original copies).

X CELL OR CLOSED □
Y CELL OR OPEN ⊟



X clustering 0.40
Y clustering 0.80
Overlap allowed 5.00
Y sliding 0.80



X clustering 0.40
Y clustering 0.80
Overlap allowed 5.00
Y sliding 0.80

□ X CELL OR CLOSED
▯ Y CELL OR OPEN

FIG. 5.9 : EXAMPLES OF GENERATED MORPHOLOGIES
(These are reduced versions of the original copies).

The open cells have been blackened to facilitate the reading of the drawing.

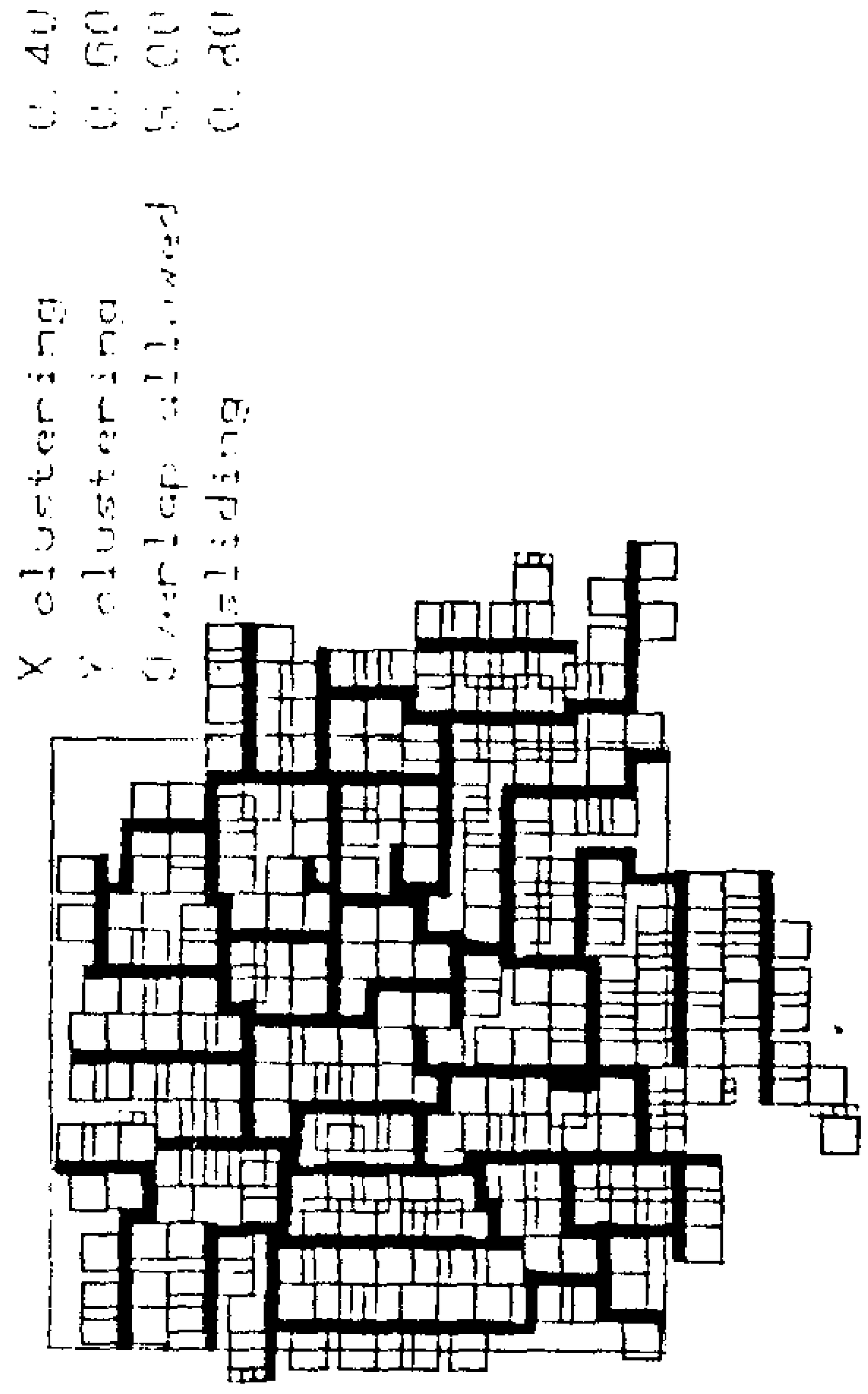
FIG. 5.10 : EXAMPLES OF GENERATED MORPHOLOGIES

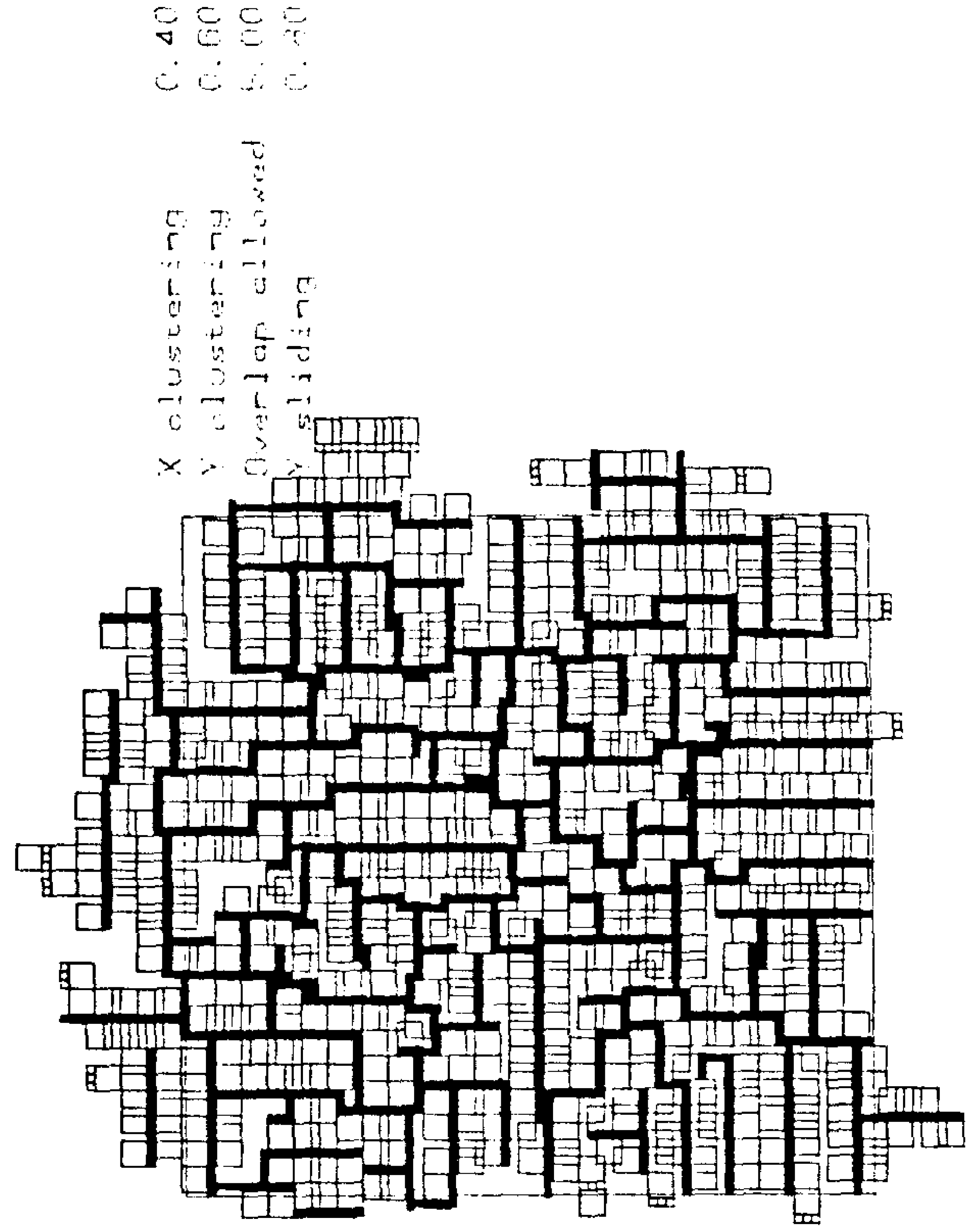
X CELL OR CLOSED □
Y CELL OR OPEN

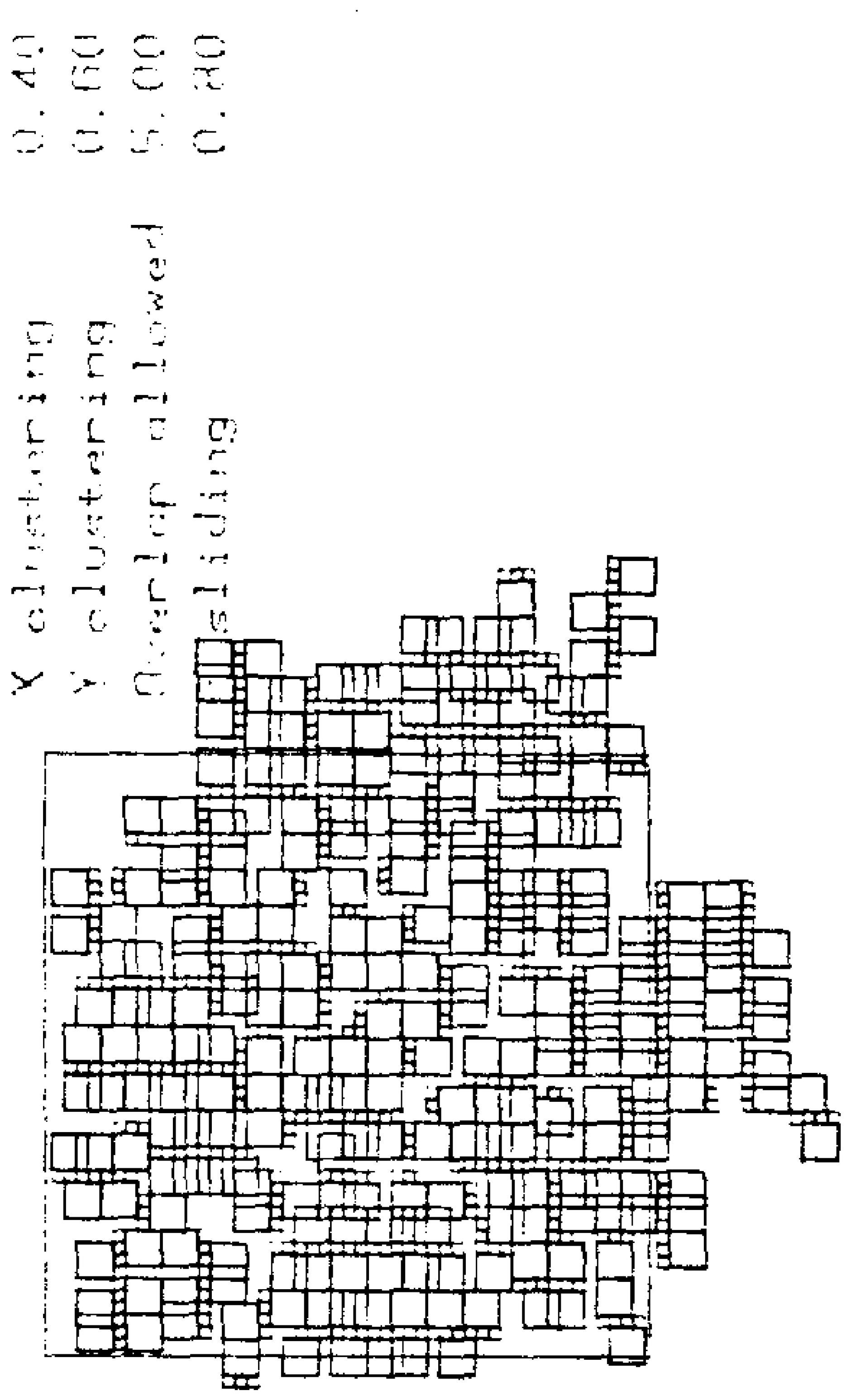
the square does not seem to introduce new spatial feature to the outcome morphologies. Only a substantial increase in either the x clustering or the y joining probabilities, seems to bias the morphology towards either an x or a y-led systems. For example, when Px is set to 0.8 and Py to 0.6, the outcome of this combination presents very large blocks of x cells with the y cells forming clusters, which are in some cases entirely surrounded by closed cells, as it is the case of morphologies produced by insisting only on x clustering and randomizing the y joining as shown above in figures 5.5, 5.6.

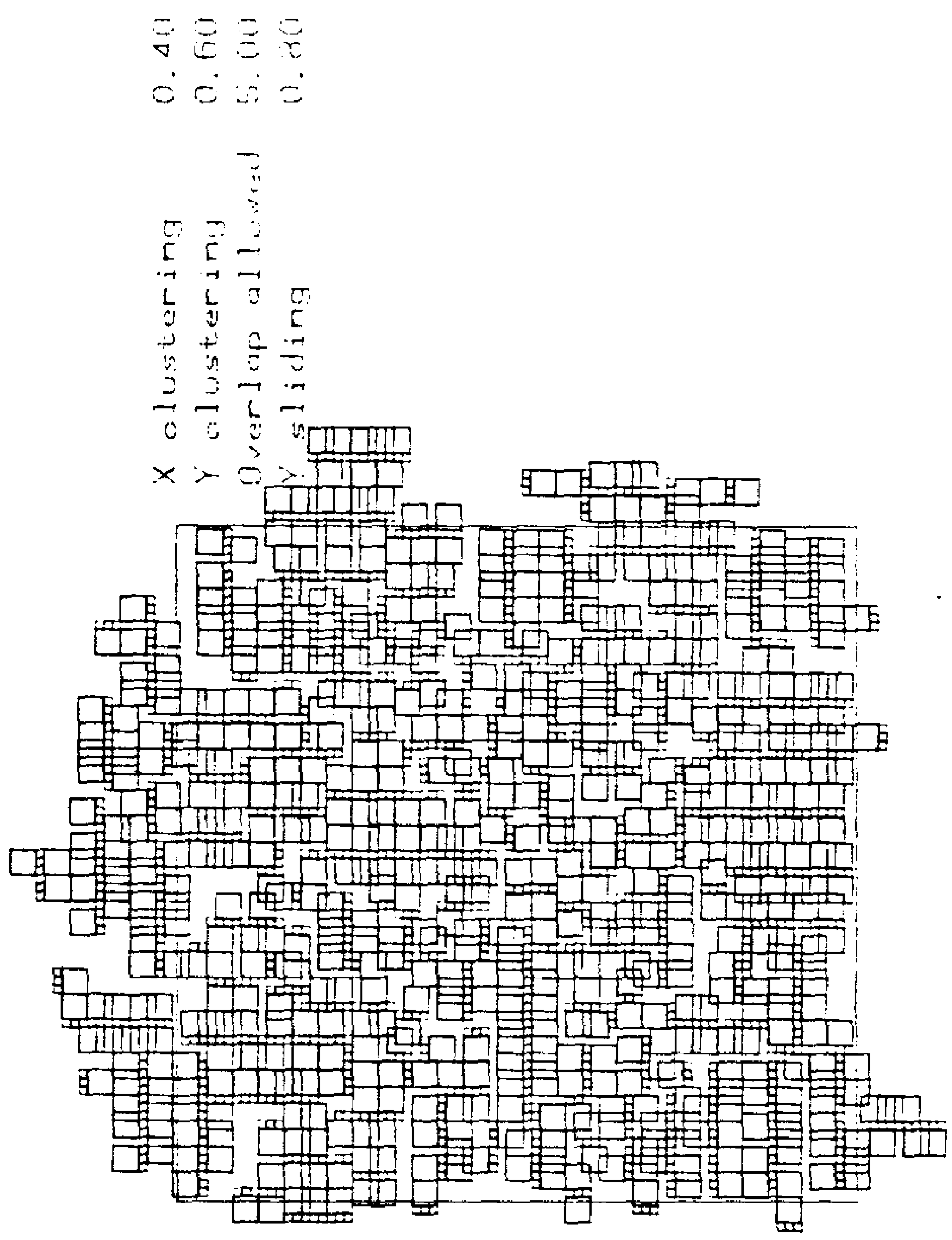
On the other hand and as shown in figures 5.9 and 5.10, when Py is set to 0.8 and Px to 0.4 (or Px=0.6), the outcome morphologies are similar to the ones produced by insisting only on y joining and randomizing the position of x cells, with the difference that these present denser fabric, in the sense that there are less of the unallocated spaces as observed in the morphologies generated by Py=0.8 and Px=0.

A casual examination of some of the simulated morphologies as illustrated by figure 5.11, suggests certain resemblance with the real examples, especially in terms of the dense fabric of the blocks and the highly deformed grid of the resulting y structure.





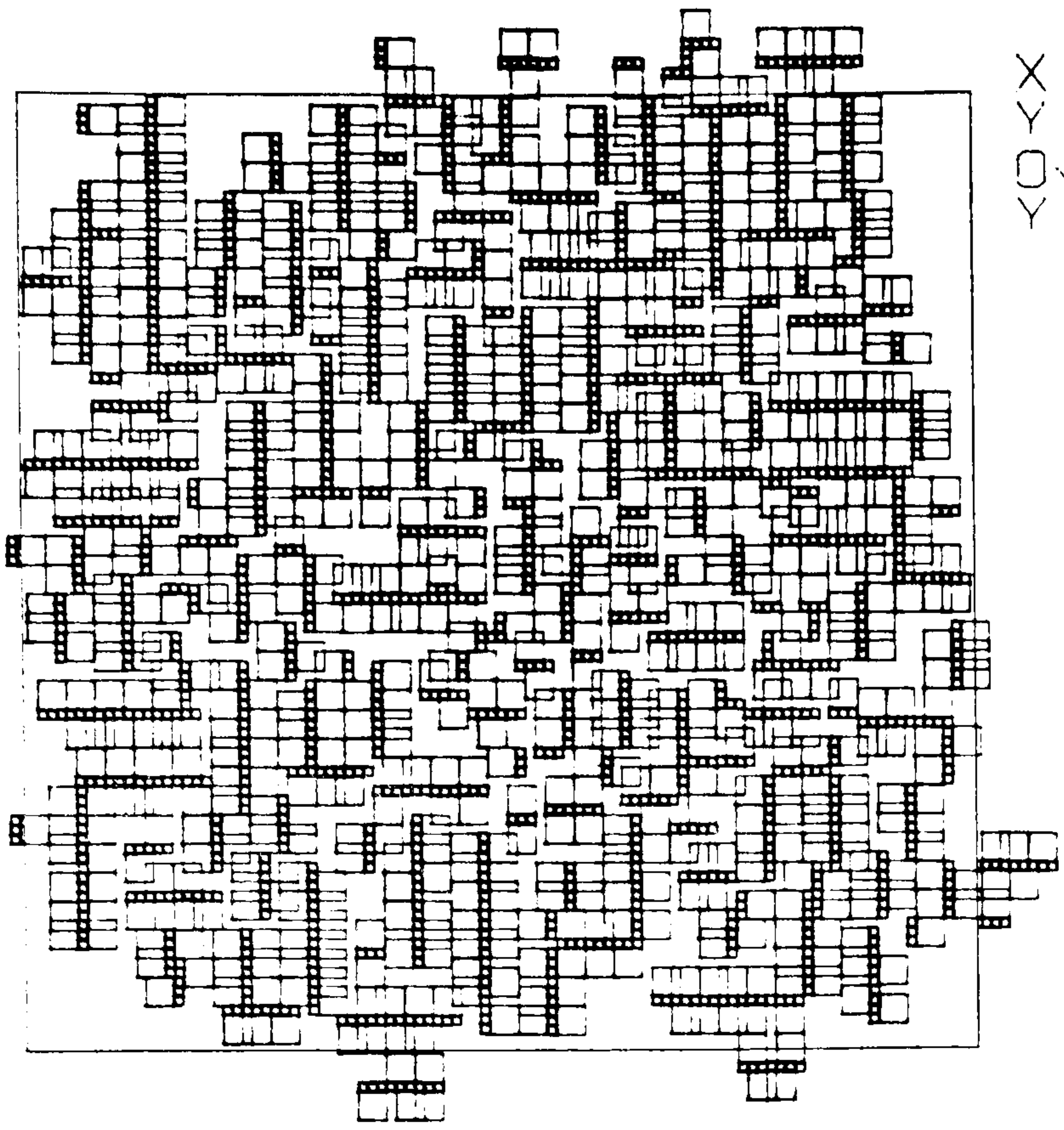




X CELL OR CLOSED □
Y CELL OR OPEN B

FIG. 5.11 : EXAMPLES OF GENERATED MORPHOLOGIES AT THREE SIZES OF THE FRAME.
(These are reduced versions of the original copies).

The open cells have been blackened to facilitate the reading of the drawing.



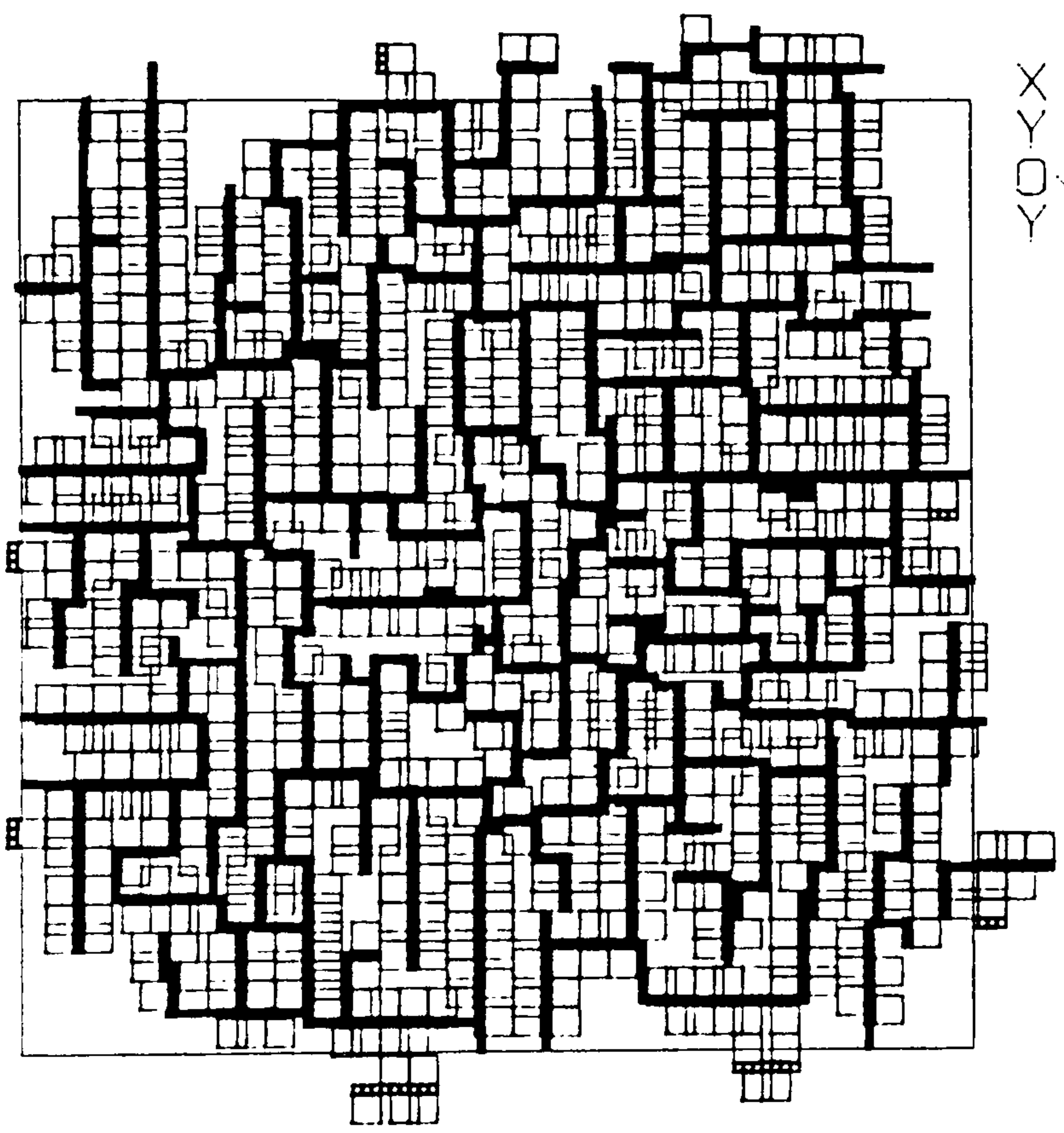


FIG. 5.11 (CONTINUED)

SPATIAL ANALYSIS AND COMPARISON:

INTRODUCTION:

Only a limited number of the computer-generated morphologies will be analysed, 70 systems altogether. These are the ones which present some apparent similarities to visual inspection with the real examples; that is morphologies with large "clusters" of closed cells, and many cul-de-sacs, as well as a fairly continuous structure of the open cells (see figures 5.9 to 5.11). Therefore, the criteria for the selection are: i- continuity of the y structure ii- density of the x structure; iii- reasonable range of variation in the parameters.

However, it must be noted that these examples represent only a small range of the possibilities in morphological terms, that are open to the model. As already pointed out, three parameters (X clustering, Y joining and Y sliding) are built into the model which are all to be applied probabilistically on a range from 0 to 1, giving therefore a large number of possible combinations of 1331. The fourth parameter is the overlap rule for the x cells which ranges from 0 to 9. But only 7 values are in fact feasible, and this gives a total number of possible combinations of 9317. This is so without taking into account the effect of the random numbers (*).

* The effect of the random series has not been tested in the present study.

Eight different sets of values of the X clustering (Px), Y joining (Py) and Y sliding (Ps) have been generated, always by varying one parameter at a time and keeping the other two constant. These are a follows:

<u>Set</u> <u>1</u>: Px=0, Py=0.6, Overlap=5, Ps=0.8.

<u>Set</u> <u>2</u>: Px=0.4, Py=0.6, overlap=5, Ps=0.8.

<u>Set</u> <u>3</u>: Px=0.6, Py=0.6, overlap=5, Ps=0.8.

<u>Set</u> <u>4</u>: Px=0.4, Py=0, overlap=5, Ps=0.8.

<u>Set</u> <u>5</u>: Px=0.4, Py=0.7, overlap=5, Ps=0.8.

<u>Set</u> <u>6</u>: Px=0.4, Py=0.8, overlap=5, Ps=0.8.

<u>Set</u> <u>7</u>: Px=0.4, Py=0.6, overlap=5, Ps=0.2.

<u>Set</u> <u>8</u>: Px=0.4, Py=0.6, overlap=5, Ps=0.4.

Each set of values has been generated in three different sizes of the square (50x50, 80x80, 100x100), and for each size, three simulations have been produced. This makes a total of 9 runs for each set of values given to the three variables (x clustering, y joining and y sliding), in order to reduce the contingent factor.

The spatial analysis of the morphologies generated by the computer is based on the same analytical tools used in the analysis of the real examples. To avoid tautologies, the analytical variables must describe the properties of the simulated morphologies that are not built into the model. These variables are in fact independent from the rules embedded in the generative program, since they describe the global properties of the morphologies (i.e. their axial organisation), while the model operates on a recursive basis by applying rules for growth which are local.

For each selected morphology, an axial map has been drawn, and the resulting network is labelled with each segment of the open cells assigned a number and the information on connectedness is used as the data for the analysis. These variables are used first, to describe and evaluate the morphological differences (if any) that occur when varying the values of the parameters; and second, to compare these simulated morphologies with the real examples.

The analytical results for the 70 generated systems have been compiled into a "synoptic" data file which gives the means, maxima and minima for all measures as well as statistical information about the relationships between the variances. The objectives of the numerical analysis of the output of the model are:

i- to examine how far the x clustering (Px), the y joining (Py) and the y sliding (Ps) correlate with the analytical measures, in each case controlling for the effect of size (K).

ii- to examine the extent to which the generative parameters (Px, Py, Ps) correlate with the size of the blocks of x cells.

iii- to carry out a three-way comparison of the analytic measures, and examine their means and distribution and see the extent to which they correlate with each other and with the size of the systems; using the 70 simulated morphologies as one group, the 75 urban systems of the SERC report as a second group and the real cases of the towns under study as a third group.

iv- to examine the relation between the generative parameters and the structure of the integration core.

RELATION BETWEEN GENERATIVE PARAMETERS AND ANALYTIC MEASURES:

In the following sections, an attempt will be made to look at the effect of the generative principles on the spatial structure of the outcome morphologies. This will be done by varying one parameter at a time, controlling for the effect of size.

THE EFFECT OF X CLUSTERING:

VARIABLE	X CLUST	X CLUST control for K
K	0.294	-
Mean CN	-0.107	-0.118
Max. CN	0.126	0.008
Mean RRA	0.589	0.616
Max. RRA	0.550	0.500
Min. RRA	0.590	0.584
1:RA/CN	-0.512	-0.439
1:RA/RCH	-0.337	-0.264
CN/CH	-0.385	-0.311

TABLE 5.1: RELATIONS BETWEEN THE ANALYTICAL MEASURES AND THE X CLUSTERING.

Table 5.1 gives a summary of the correlations between the analytical measures and the x clustering parameters, controlling for the effect of size (expressed by log K). The results show:

- a weak correlation between the x clustering and size (K), which means that the number of axial lines increases very little when the x clustering is raised.

- the mean integration correlates positively with x clustering (0.589), and rises to 0.616 when the size is controlled for.

- the maximum integration also correlates significantly with x clustering and does not improve when the size is controlled for.

- the mean connectivity remains constant with the increase in x clustering, and so does the maximum connectivity.

- the degree of agreement between connectivity and integration falls substantially with the increase of x clustering (-0.512) and decreases (-0.439) when the effect of size is discounted.

- the global "predictability" (1:RA/RCH) decays, though only marginally, with the increase in x clustering. The correlation between the two parameters becomes almost random (non-existent) when the size is controlled for.

- the local "predictability" (CN/CH) also drops with the increase of x clustering, but only very weakly; the correlation between the two parameters being only -0.385 and remains constant when the size is controlled for.

The above results point to the general conclusion that the x clustering has a strong effect on the level of integration, and to a much lesser extent on the "intelligibility" of the systems, which worsen regardless of the size of the systems. It has also been shown that the mean and the maximum connectivity are not affected by the variation of this generative parameter.

THE EFFECT OF THE Y JOINING RULE:

The key results of the relations between the y joining rule and the syntactic measures are shown in Table 5.2.

VARIABLE	Y JOINING	Y JOINING control for K
K	-0.115	-
Mean CN	0.783	0.803
Max. CN	0.593	0.724
Mean RRA	-0.756	-0.868
Max. RRA	-0.744	-0.815
Min. RRA	-0.679	-0.764
1:RA/CN	0.463	0.512
1:RA/RCH	0.343	0.325
CN/CH	0.486	0.552

TABLE 5.2: RELATIONS BETWEEN THE ANALYTICAL MEASURES AND THE Y JOINING.

These can be summarized as follows:

- the y joining does not correlate with the size of the morphologies, which is given by the number of axial lines representing the systems.

- the mean integration improves very strongly with the increase of y joining; the correlation being -0.756 rising to -0.868 when the effect of size is removed.

- the maximum integration also strongly correlates, but negatively, with y joining and improves dramatically when the size is controlled for.

- the mean connectivity increases very substantially with the increase in y joining; the correlation being 0.783 improving to 0.803 when the size is controlled for.

- the maximum connectivity correlates with the y joining but not so strongly (0.593), but improves significantly to (0.724) when the effect of size is controlled for.

- the "intelligibility" correlates positively with y joining but not strongly (0.463), and rises to 0.512 when K is controlled for.

- the predictability given by the integration correlates very weakly with the y joining and is not affected by the removal of the effect of K.

- the predictability given by the connectivity improves with the y joining, but not so strongly (0.486 rising to 0.552 when K is controlled for).

These results clearly show that the y joining rule has considerable effects on the output morphologies. These can be summarized as follows:

i- there is no correlation between the size of the morphologies given by the number of axial lines, and the y joining parameter; but there is a clear increase in the axiality of the systems as the y joining is increased.

ii- for the generated cases and regardless of the size of the morphology, there is a marked improvement in the level of integration as the y joining is increased.

iii- the mean and the maximum connectivity are strongly affected by the y joining and that is regardless of size.

iv- the "intelligibility" and the "predictability" given by the connectivity also improve with the y joining, although not considerably.

THE EFFECT OF THE Y SLIDING RULE:

The results of the variation of the y sliding rule are shown in Table 5.3.

VARIABLE	Y SLIDE	Y SLIDE control for K
K	-0.090	-
Mean CN	0.283	0.278
Max. CN	-0.025	-0.019
Mean RRA	-0.383	-0.417
Max. RRA	-0.475	-0.525
Min. RRA	-0.348	-0.370
1:RA/CN	0.239	0.233
1:RA/RCH	0.342	0.344
CN/CH	0.154	0.144

TABLE 5.3: RELATIONS BETWEEN THE ANALYTICAL MEASURES AND THE Y SLIDING

The table shows that:

- the size of the system does not correlate with the y sliding rule (-0.09).

- there is a slight improvement in the level of integration as the y sliding increases. The correlation between the mean RRA and the y sliding is -0.388, rising to -0.417 when the size is controlled for; and the correlation between the maximum RRA and the y sliding is -0.475, improving to -0.525 with size controlled for.

- the mean connectivity remains constant when the y sliding is increased (0.283) and so does the maximum connectivity.

- there is very weak correlation between the "intelligibility" and the y sliding.

- the predictability given by the integration does not correlate with the y sliding (0.344 with K controlled for).

- the predictability given by the connectivity does not correlate with the sliding (0.144 when K is controlled for). The relation between the two parameters seems to be random.

The above results point to the conclusion that the y sliding rule does affect, but only marginally, the level of integration of the systems. The mean and maximum integration have shown to improve, although only very weakly, as the y sliding is increased; whilst the other measures tend to vary randomly.

THE BLOCK FORMATION AND THE GENERATIVE RULES:

The size of the blocks is given by the number of closed cells it contains. Table 5.4 sets out the average, maximum and minimum block size in relation to the generative parameters, x clustering, y joining and y sliding. The number of blocks considered in this exercise totals to 1375, taken from 50 different morphologies (see Appendix 2).

VARIABLE	NUMBER OF BLOCKS	MEAN SIZE	MAX SIZE	MIN SIZE
X0Y0	82	3.063	14.00	1
X4Y0	177	13.534	44.38	2.88
X6Y0	39	22.34	56.50	5.75
X0Y0	82	3.06	14.00	1
X0Y4	133	11.52	31	2.75
X0Y8	103	8.15	32.33	2.00
X4Y0	177	13.534	44.38	2.88
X4Y2	135	8.96	32.33	2.33
X4Y6	135	13,54	45.00	3.20
X4Y7	137	10.29	42.33	2.00
X4Y8	148	10.93	43.83	1.67
X0Y6	133	11.52	31.00	2.75
X4Y6	135	13.54	45.00	3.20
X6Y6	180	14.03	47.00	3.57
X8Y6	106	16.26	47.33	4.33

TABLE 5.4: RELATIONS OF BLOCK SIZE WITH THE GENERATIVE PARAMETERS, USING 50 CASES OF THE GENERATED SYSTEMS, (1375 BLOCKS).

X and Y in the table refers to x clustering and y joining respectively. X0, X4, X6, X8 refer to the different probability values given to x clustering. Y0, Y2, Y4, Y6, Y8 also refer to the probability values given to the y joining parameter. In fact 2 refers to 0.2, 4 to 0.4...

The procedure adopted to look at the relationship between the block formation and the generative parameters is:

i- to examine the relation of the block size (mean and distribution) and x clustering, while randomizing the y joining and keeping y sliding constant.

ii- to examine the relation of the block size and y joining, while randomizing the x clustering.

iii- to examine the relation of the block size and the x clustering, while the y joining is not random but set to a constant value; i.e. varying x clustering from Px=0 to Px=0.8, while y joining for all the runs is set to 0.6.

iv- to examine the relation of the block size and the y joining, while x clustering is not randomized but set to a constant value.

The aim of this section is not only to isolate the individual effect of the generative parameters taken separately but also to look at the dual effect of the x clustering and y joining as this seems to have some bearing on the size and shape (square-like or more elongated) of the blocks.

Table 5.5 gives the statistical correlations between the size of the blocks and the generative parameters.

VARIABLE	MEAN(*)	MAX	MIN	ST DEV.
X CLUST, Y RANDOM	0.755	0.490	0.750	0.587
Y JOIN, X RANDOM	0.757	0.715	0.724	0.730
X CLUST, Py=0.6	0.577	0.560	0.629	0.628
Y JOIN, Px=0.4	0.196	0.033	0.053	0.122

TABLE 5.5: CORRELATIONS BETWEEN THE GENERATIVE PARAMETERS AND THE SIZE OF BLOCKS.

Tables 5.4 and 5.5 show that:

- the blocks vary considerably in size, in most cases, ranging from blocks of 1 to 106 closed cells.

- the increase in x clustering, as expected, has a powerful effect on the size of the blocks. When x clustering is increased from random to a probability of 0.6, while y joining is randomized, the average block contains from 3 to 22 closed cells, while the largest blocks contain from 14 to 106 cells. The increase in x clustering correlates strongly with the block size (0.755). There is a clear tendency to increase the average block size as the x clustering is increased while maintaining y joining random.

- the increase in the joining probabilities of the open

* MEAN, MAX, MIN refer to the means of the mean block sizes, the means of the maximum block size and the means of the minimum block sizes.

cells, results also in an increase in the size of the blocks of closed cells, but not to the same extent as for the x clustering. When the y joining probabilities are increased from a random to a value of 0.8, the average size of the blocks increases from approximately 3 to 11 and then drops to 8 cells. In other words, there is no systematic variation between the two parameters.

- the increase of the y joining, while x clustering is not randomized but set to a probability of 0.4, does not seem to affect strongly the block size. The relation between the two tends to be random, with a correlation coefficient of only 0.196.

- the increase of x clustering, while y joining is not randomized but set to a constant value of 0.6, results in an increase in the block size. The correlation between the x clustering and the average block size is 0.577.

- the sliding rule does not seem to have any strong effect on the size of the blocks. The relation of the sliding rule with the size of the blocks tends to be random.

The examination of the systems used in this section from the point of view of the overall shape of the blocks suggests that:

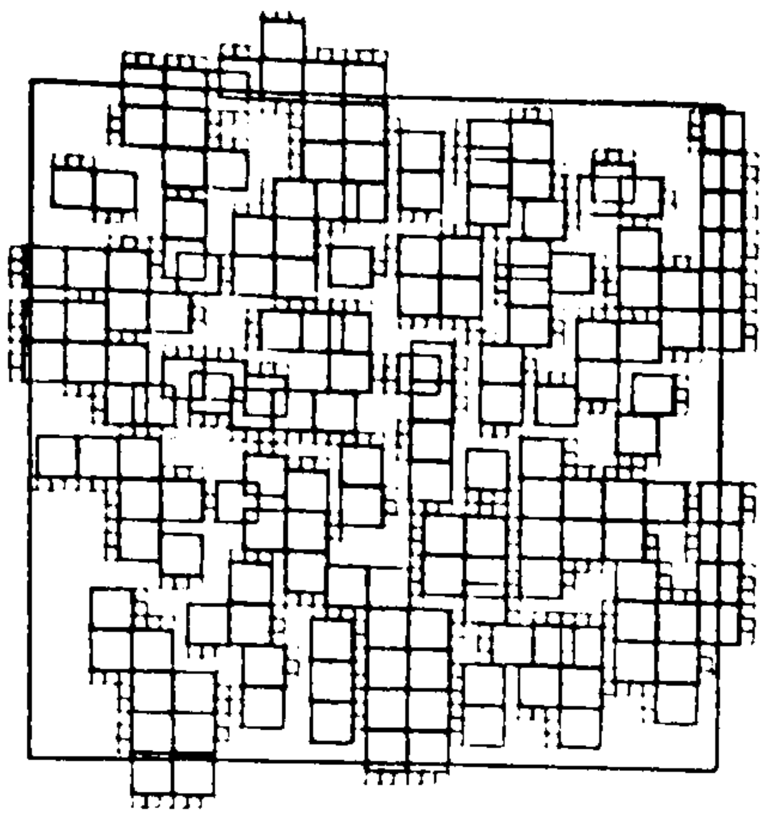
i- the increase in the x clustering seems to generate blocks which tend to expand much more in two directions, resulting in very irregular shapes (see fig. 5.12).

ii- the increase of the y joining tends to produce blocks of more elongated shape (see fig. 5.13).

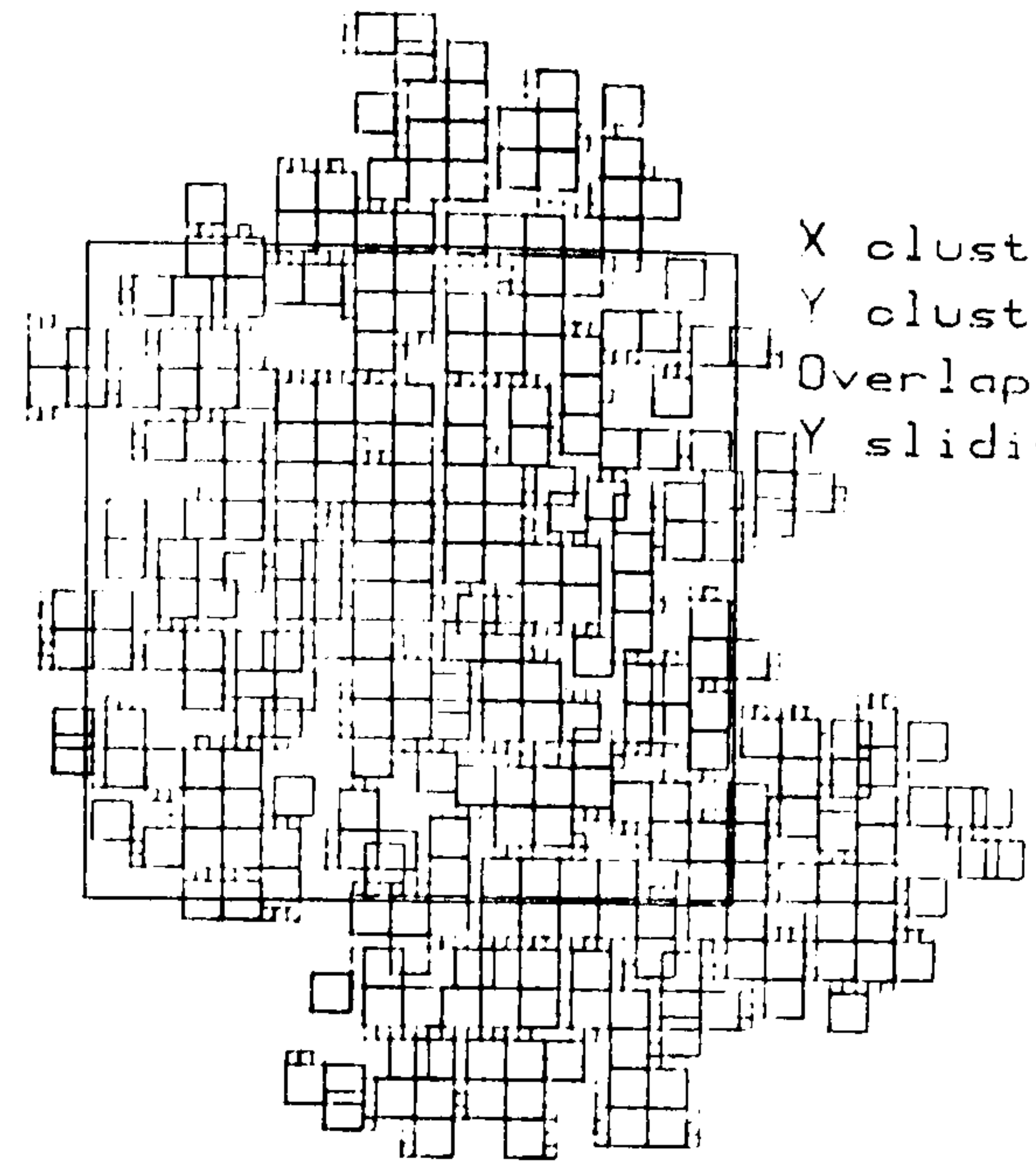
iii- the increase in both x and y joining (i.e., Px=0.6, Py=0.6) seems to result in more regular blocks in terms of size and shape. These are in general square in shape and contain between 11 to 16 closed cells (see fig. 5.14). In this case there is a clear tendency for the x cells to form "clumps" rather than "strings".

The above results suggest that the insistence on the clustering of the closed cells generate much lower levels of integration and also larger blocks. This is only possible if the morphology grows by adding more closed cells in two directions, that is by increasing the size of the blocks not linearly but more squarely, creating therefore a more fragmented structure of the open cells, since every closed cell is attached to its attendant y cell. The importance of this result can be better seen in the context of the terrace system formation.

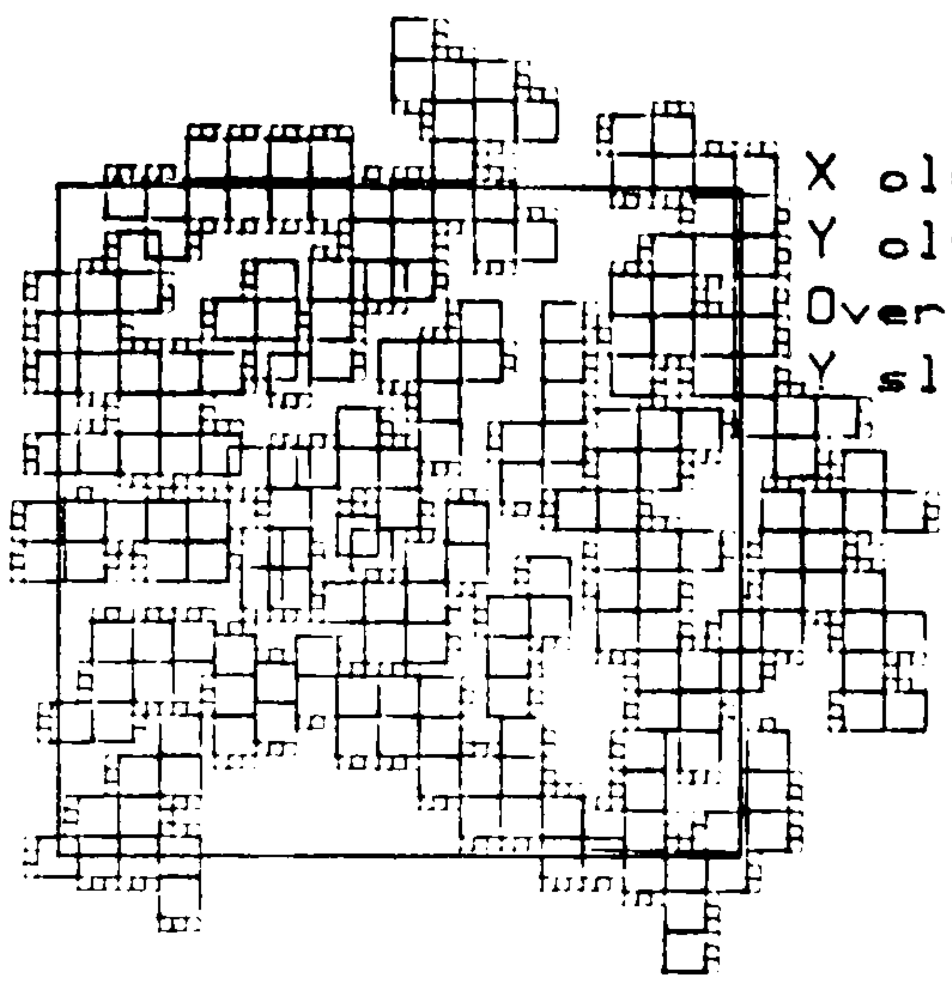
The fact that the increase of the x clustering results not only in an increase in the degree of segregation of the spatial fabric, but also in an increase of the size of the blocks suggests a relationship between the



X clustering 0.40
Y clustering 0.00
Overlap allowed 5.00
Y sliding 0.80

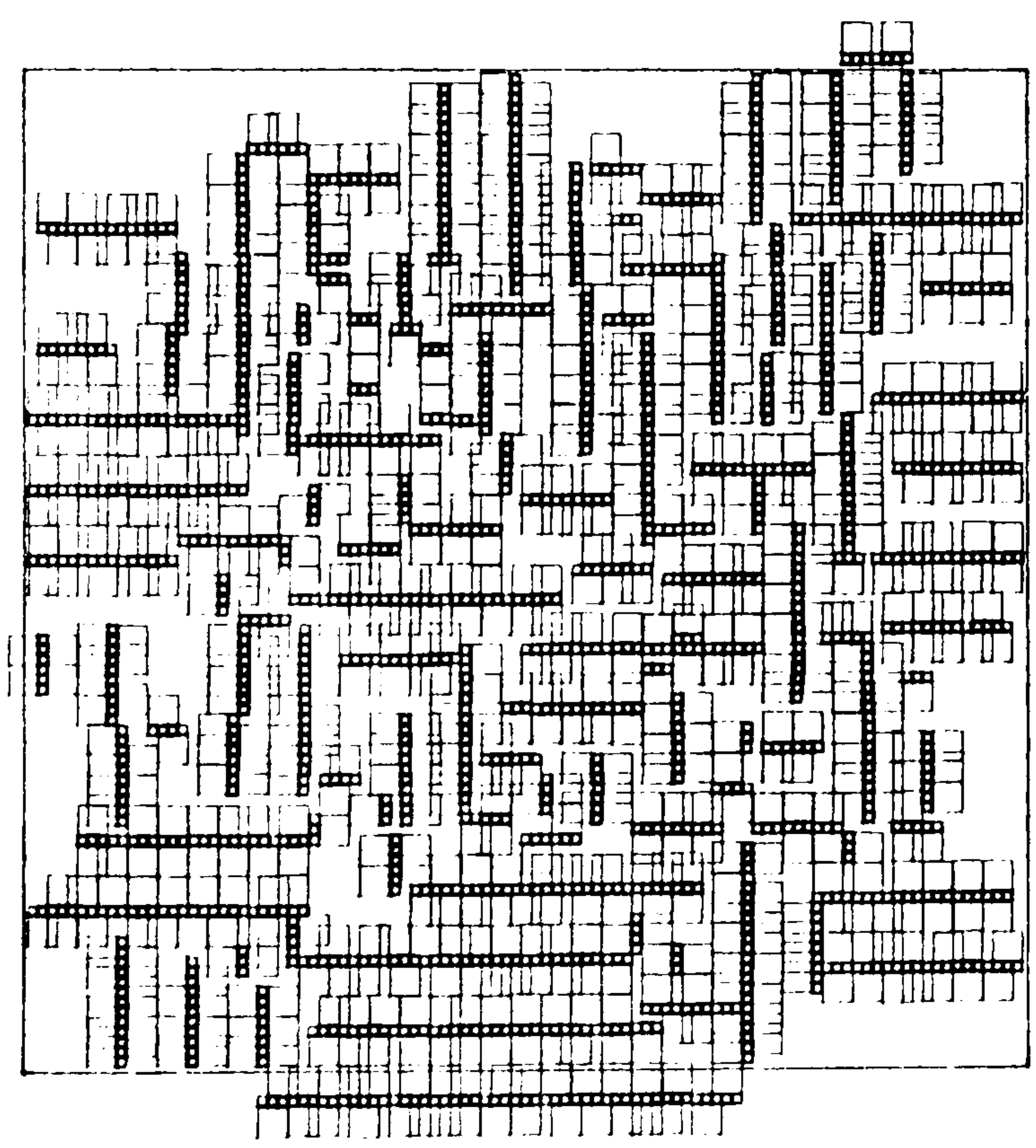


X clustering 0.80
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.80

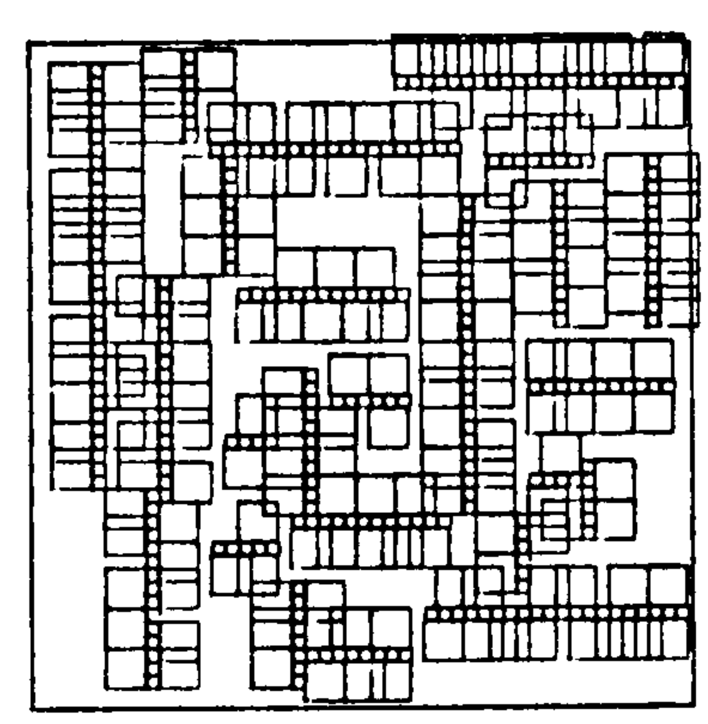


X clustering 0.60
Y clustering 0.00
Overlap allowed 5.00
Y sliding 0.80

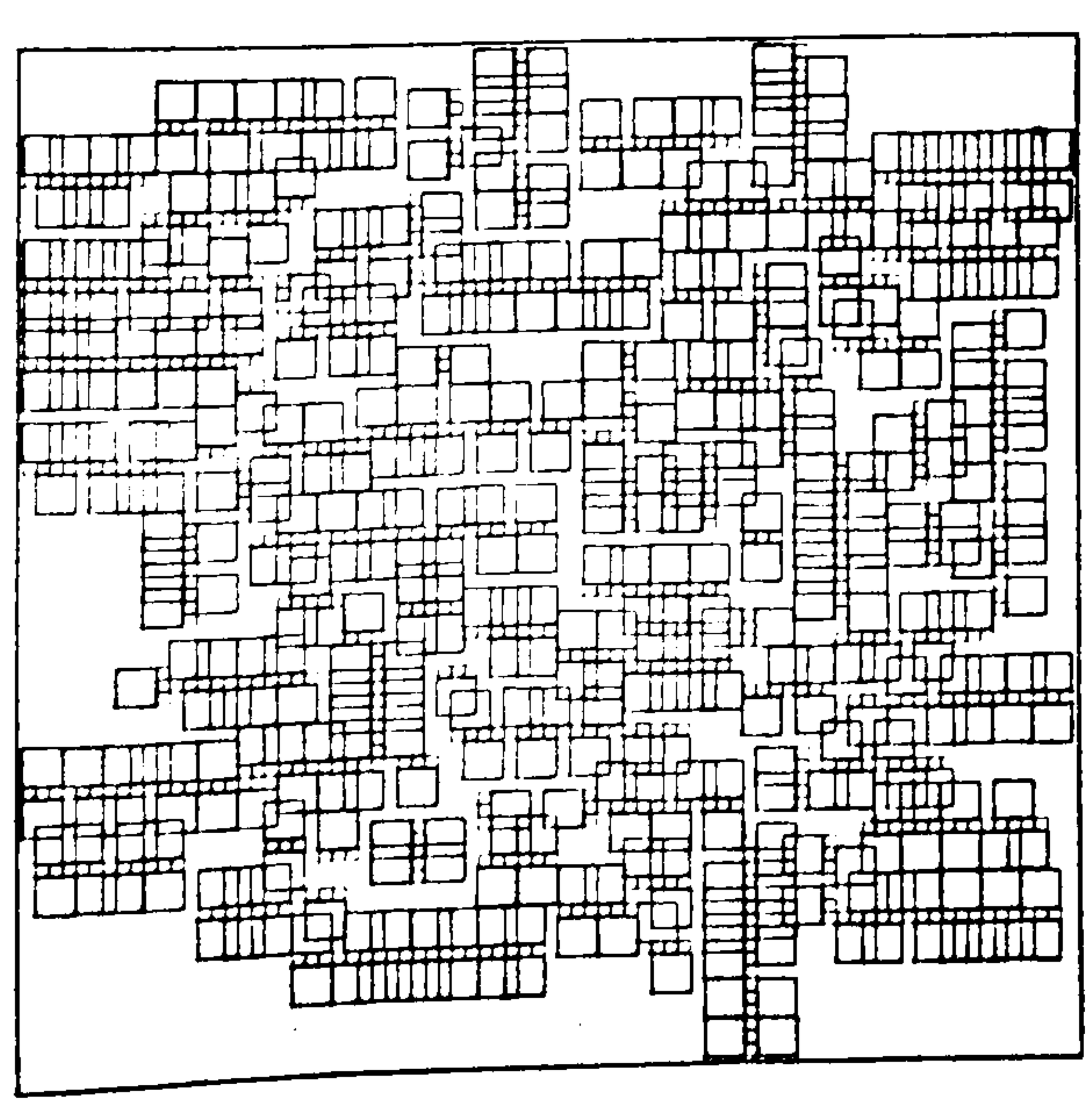
FIG. 5.12 : BLOCK FORMATION, WHEN INSISTING ON X CLUSTERING
(These are reduced versions of the original copies).



X clustering 0.40
Y clustering 0.80
Overlap allowed 5.00
Y sliding 0.80



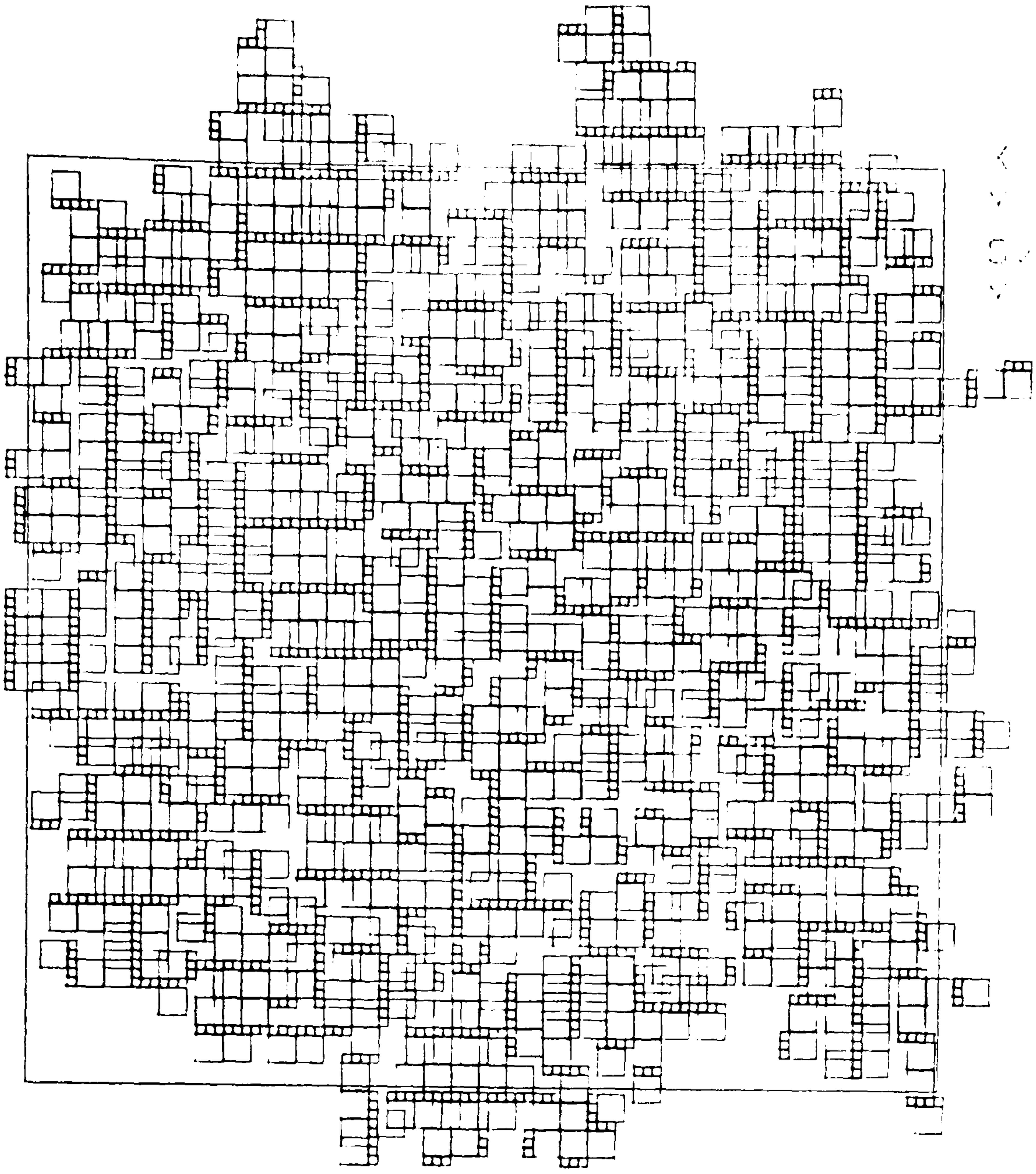
X clustering 0.00
Y clustering 0.70
Overlap allowed 5.00
Y sliding 0.80

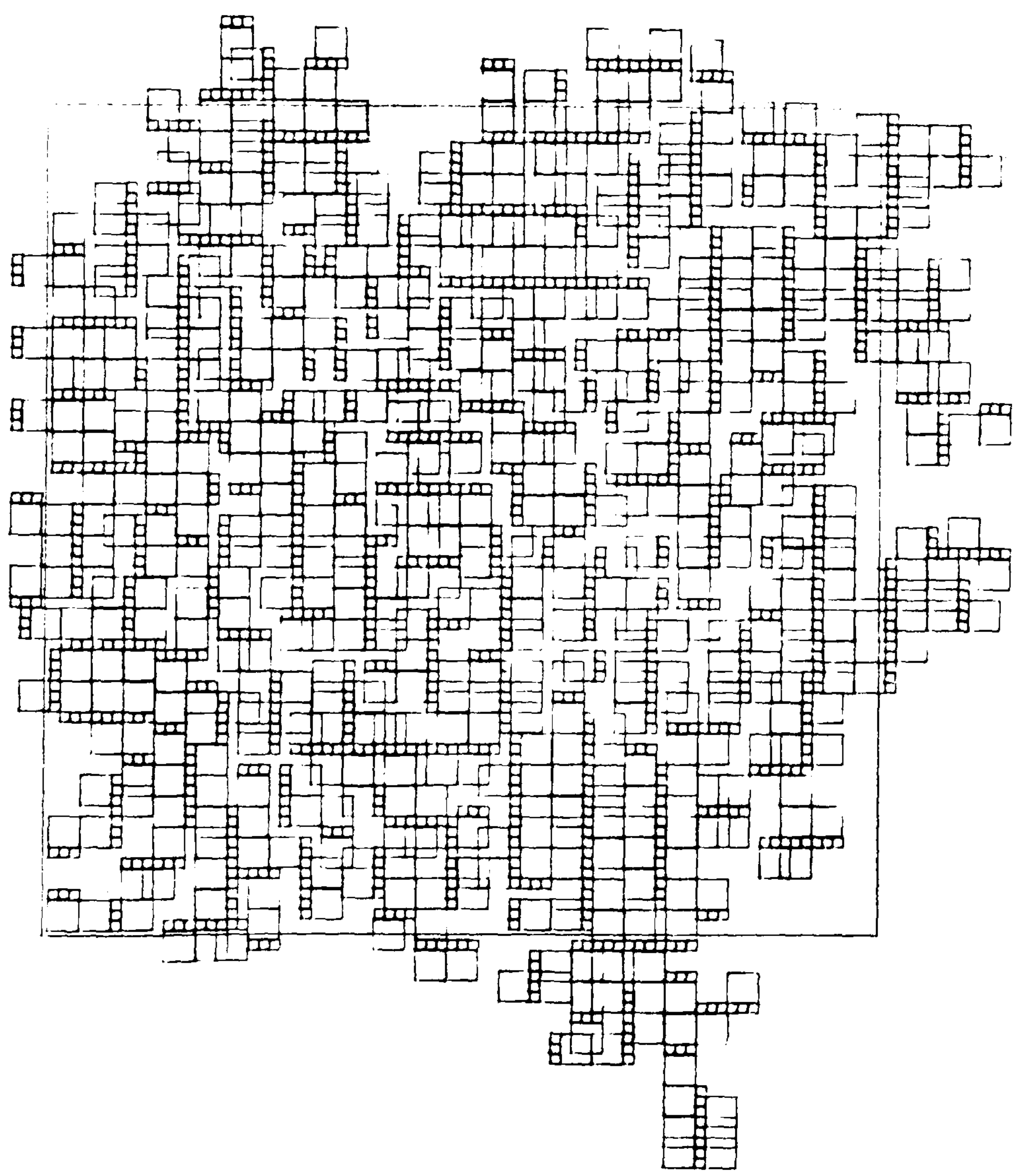


X clustering 0.00
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.80

FIG. 5.13 : BLOCK FORMATION, WHEN INSISTING ON Y JOINING
(These are reduced versions of the original copies).

X CELL OR CLOSED □
Y CELL OR OPEN ▯





X CLUSTERING	0.60
Y CLUSTERING	0.60
OVERLAP ALLOWED	5.00
Y SLIDING	0.80

FIG. 5.14: BLOCK FORMATION WHEN INSISTING ON BOTH, X CLUSTERING AND Y JOINING.

X CELL OR CLOSED □

Y CELL OR OPEN

degree of segregation in the town fabric and its potentiality to develop the terrace system. The ground plan of Ghardaia and Beni Isguen in particular show clearly that the blocks become more linear; and the terrace system becomes also much less developed in the more recent part of the town. On the other hand, the analysis (BI1) has shown an improvement in the level of integration of the spatial fabric, as the town grows. This suggests then, that Beni Isguen, as it grows, may have followed a more y-led process which explains perhaps, why the terraces occur to a much lesser extent in the newer part of the town.

COMPARISON OF THE GENERATED MORPHOLOGIES AND THE REAL CASES:

MEANS OF	CN	RRA	1:RA/CN	1:RA/RCH	CN/CN
MEAN (r:K)	2.646 (0.043)	1.509 (0.623)	0.202 -	0.527 -	0.450 -
MAX. (r:K)	5.971 (0.388)	2.014 (0.560)	0.513	0.763	0.712
MIN.	1.943	1.107	0.044	0.336	0.226
r:K(*)	-	-	-0.630	-0.340	-0.507

TABLE 5.6: MEASURES FOR THE 70 COMPUTER GENERATED SYSTEMS.

Table 5.6 sets out the means of means for the measures (*) for the 70 computer generated systems, and shows their behaviour with the size of the systems (K) given by the number of axial lines, and which varies between 33 and 246.

The results show that:

- the mean connectivity for the generated morphologies is 2.646 compared to 3.596 (for the 75 urban systems), and does not correlate significantly with the size (0.043). The computer generated systems do not increase their mean connectivity as they grow.

- unlike the 75 urban systems, the maximum connectivity does not increase in a significant manner with size (0.388 as opposed to 0.765).

- the mean integration for the 70 runs of the model is well below the average for the 75 urban systems (1.509 compared to 0.934), and strongly falls with size (0.623 as opposed to 0.053 for the 75 urban systems).

- the average level of correlation between connectivity and integration (i.e. intelligibility for the real systems) is very low (0.202 as opposed to 0.686) and strongly decreases with size.

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* The mean for the correlation coefficients (i.e. 1:RA/CN) for the whole sample have been derived from the squared values of the variances in order to overcome the problem of negative correlations. This is why the means are much lower than the original values computed for each case separately, (0.4 x 0.4 = 0.16). Any comparison must take into account this fact, and must make sure that the systems to be compared to have been submitted to the same mathematical transformation.

- the mean correlation between the integration and choice is also very low (0.527 compared to 0.74 for the 75 urban cases) and so is the mean correlation between connectivity and choice (0.450 compared to 0.768).

	CN	RRA	1:RA/CN	1:RA/RCH	CN/CH
MEAN (K)	2.619 (-0.017)	1.599 (0.424)	0.289	0.496	0.379
MAX. (K)	6.000 (0.763)	2.362 (0.272)	0.577	0.792	0.740
MIN. (K)	1.889 (-0.590)	1.155 (0.517)	0.078	0.219	0.256
r:K	-	-	-0.641	-0.695	-0.410

TABLE 5.7: MEASURES FOR THE REAL TOWNS UNDER STUDY.

Table 5.7 presents a summary of the numerical characteristics for the sample of the towns under examination. The tables show that:

- the comparison of the integration measures shows that the values for the hypothetical cases fall well within the range of values produced by the analysis of the real examples.

In both sets of data,

- the mean connectivity does not correlate with size.

- the maximum connectivity correlates much more strongly with size in the real systems than it does in the generated morphologies.

- The correlation between the mean integration and size is much stronger in the simulated systems (0.623) than it is in the real cases (0.424). The level of integration is created by the connectivity. In the real cases, there is an increase in the connectivity of only few spaces (i.e. the market area in Ghardaia) which will produce a certain pattern of integration; but this increase is not assigned to so many spaces as would improve the level of connectivity and integration or would create the "super-grid" effect as observed in some urban systems (i.e. SERC Report, 1986, pp. 9-10). This is an indication that in real situations, there seems to be a change of the rules and discrimination between certain parts of the town in order to control the morphological effects of growth, i.e. to control the increase of the level of segregation. This change in the rules does not take place in the generated morphologies, because the rules embedded in the model are equally applied all over the surface.

- For all three sets of data (*), the intelligibility correlates significantly with size; it falls when the systems become larger.

* The three sets of data refer to the 75 urban systems, the 70 computer generated systems and the towns under study.

	K	1:RA/CN	1:RA/RCH	CN/CH
MEAN CN	0.043	0.169	0.177	0.122
MAX. CN	0.388	-0.192	-0.285	-0.171
MEAN RRA	0.623	-0.724	-0.520	-0.724
(control K)	-	(-0.515)	(-0.435)	(-0.579)
MAX. RRA	0.560	-0.691	-0.592	-0.649
(control K)	-	(-0.429)	(-0.527)	(-0.491)
MIN. RRA	0.564	-0.643	-0.421	-0.674
(control K)	-	(-0.403)	(-0.307)	(-0.521)
1:RA/CN	-0.630	-	0.436	0.808
(control. K)	-	-	(0.258)	(0.708)
(cont.MEANRRA)	-	-	(0.031)	(0.597)
1:RA/RCH	-0.340	0.436	-	0.362
(control. K)	-	(0.258)	-	(0.236)
(cont.MEANRRA)	-	(0.031)	-	(-.026)

TABLE 5.8: SYNOPTIC CORRELATIONS FOR THE 70 SIMULATED SYSTEMS.

Table 5.8 indicates the inter-relationships between the spatial measures and shows:

- a strong correlation between the mean integration and the intelligibility (-0.724) which decays to 0.515 when the size effect is discounted. This is the contrary result to the 75 urban systems in which the correlation between the mean integration and intelligibility is also high (-0.527) but becomes much stronger (-0.714) when the effect of size is controlled for (see SERC Report, 1986, p.12).

- the mean integration correlates significantly with predictibility given by the integration (-0.520) and not at all in the 75 urban systems (0.002) (SERC Report, 1986, p. 12).

- mean integration strongly correlates with predictibility given by the connectivity in both the 70 computer generated systems (-0.724) and the 75 urban areas (-0.716).

- for the 70 simulated systems, the correlation between intelligibility (1:RA/CN) and predictability (1:RA/RCH) is very weak, 0.436 compared to 0.787 for the 75 urban systems (SERC Report, 1986, pp. 12-13), which decays to 0.543 when the size is controlled for.

The comparison of these results to the towns under study (see Table 4.3) shows that:

- in both systems (real towns under study and hypothetical), the mean integration correlates strongly with intelligibility (-0.751 for the real systems, which becomes -0.563 when K is controlled for).

- in both systems, the mean integration does correlate with the global predictability (for the real towns, -0.626 decreasing to -0.348 when K is controlled for).

- While, the mean integration correlates much more strongly with local predictability than in the real towns and also falls when K is controlled for (-0.591 for the real towns, decaying to -0.435 when K is controlled for);

- for the simulated systems, intelligibility correlates with the global predictability almost to the same degree as in the real towns, decaying when K is controlled but much more strongly when mean RRA is controlled for (0.543 for the real towns).

The above results point to the conclusion that the generated morphologies present in spatial terms and in many respect, fundamental differences to the 75 urban systems. In fact, the comparison of the two samples show exactly the contrary properties. Most of the key properties and relations found in the real cases of the 75 urban areas are not reproduced in the 70 simulated systems. This can only lead to the suggestion that the distinctive spatial properties of the 75 urban areas may be the result of more globalizing rules imposed on the systems in order to govern the effects of growth, as conjectured in the SERC report (SERC Report, 1986, p. 14).

But, the above tables show also that the measures given by the generated systems fall well within the range of values produced by the towns under study (towns with the terrace system), suggesting that from the point of view of the numerical properties describing the spatial fabric, the generative model has led to a well-defined pattern that bore some resemblance to the patterns found in the settlements under study. These latter have been spatially characterised to present highly segregating structure which lacked intelligibility and predictability, and these properties are also prevalent in the computer generated morphologies. In other words, the degree of segregation, the lack of intelligibility and predictability may then be accounted for in terms of the generative rules and processes. Moreover, the results have shown that in both, the towns under study and the generated systems, the integration and intelligibility are affected by size, although to a varying degree; and that the relation between intelligibility and global predictability is not as strong as in the 75 urban systems and is equally affected by size and integration.

THE PATTERN OF INTEGRATION AND THE GENERATIVE RULES:

The next question raised here is to see whether there is a relationship between the generative rules and the internal structure of the integration core itself.

The pattern of integration cores found in the real case studies, with the exception of the small systems of Ghadames (*), consisted of non-covering cores with internal spaces connected to peripheral streets. That is, in no instance did of the integration cores of the large systems presented any structure reminiscent of for example, a covering or a deformed-wheel pattern (see fig. 5.15).

In these cases, the integration core does not traverse the spatial fabric, leaving therefore large areas

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* This refers only to the three quarters with the terrace system, not to Bellil.

FIG. 5.15 : INTEGRATION STRUCTURES OF THE REAL EXAMPLES.

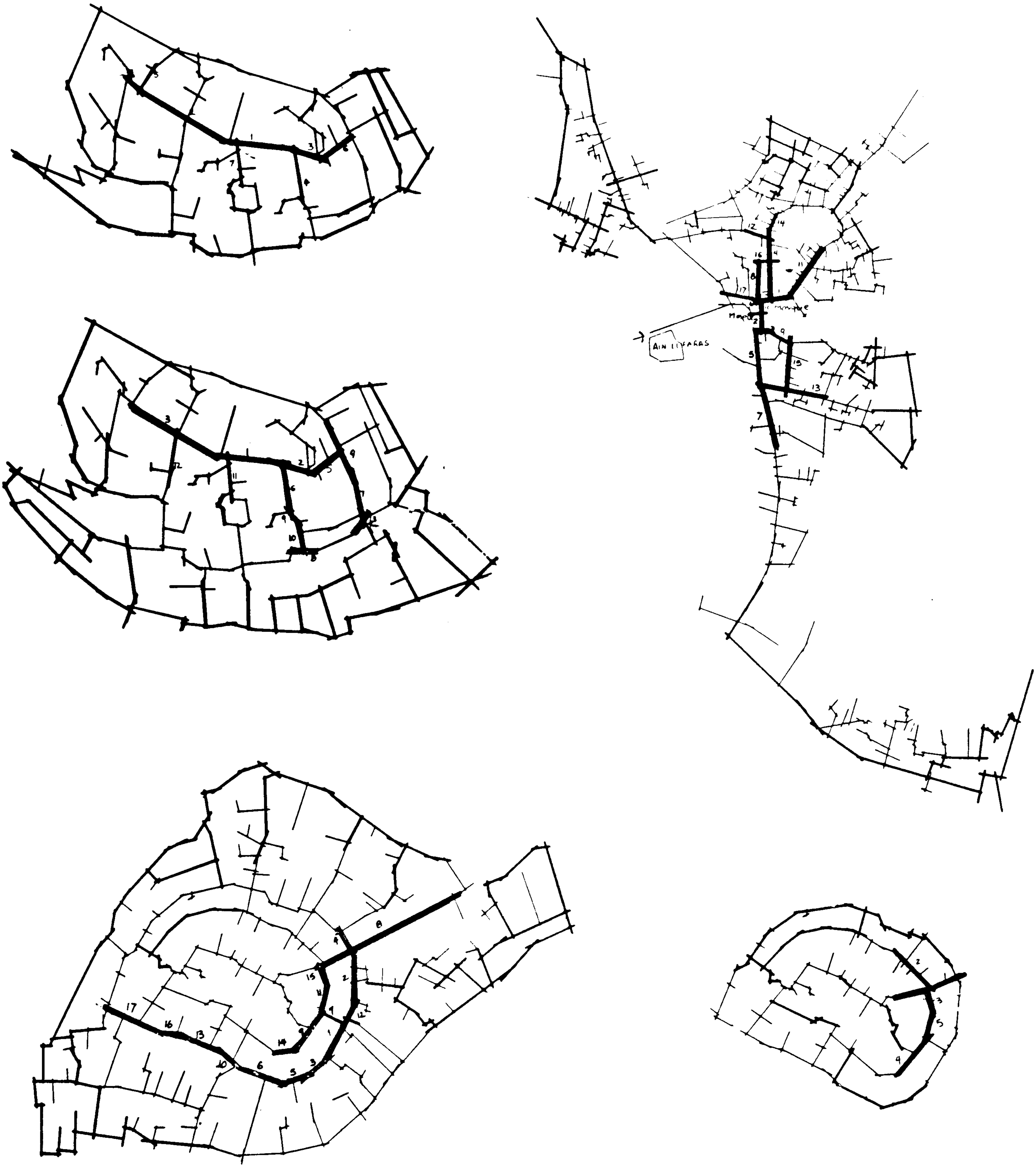


FIG. 5.15 a INTEGRATION STRUCTURES OF THE REAL EXAMPLES.

unpenetrated and highly segregated. It is conjectured that this specific distribution of the most integrated spaces on the townscape surface may originate to a great extent, from a process of growth which is based on more localized rules. Moreover, what seems important is to pinpoint the nature of these rules, and find out for example, what rule may be held more responsible for producing the peripheral and the non-covering pattern of the integration core.

The raised questions are investigated by looking at the structure of the integration cores produced by the model by varying the generative rules, one parameter at a time. The integration maps for each generated system showing the 10% of the most integrated axial lines, were prepared. The integration structure of the simulated systems will be described in terms of two main criteria which are:

First, the location of the integration core with respect to the overall morphology and with respect to the outside. Three possible locations of the core are envisaged:

i- the internal core

ii- the covering core

iii- the peripheral core

In addition to this, the connection of the core to the outside is also considered, giving therefore five possible types of cores:

- an internal core which is connected to the outside;

- an internal core with no connection to the the outside;

- a peripheral core which is in all cases linked to the outside;

- a covering core which is linked to the outside;

- a covering core which is not directly linked to the outside;

Second, the continuity of the integration structure, giving two possibilities of continuous or discontinuous core.

In the light of these criteria, the integration cores for the simulated morphologies display striking differentiation with respect to the generative rules. A casual examination of the cores indicates that none of the generated systems has produced a core which approaches the form of a covering core or a deformed wheel. Four dominant patterns have emerged from the sample.

- Pattern One includes continuous cores that are constituted by many internal lines compactly arranged, linked only by fewer lines to the outside of the morphology (see fig. 5.16, 5.16a, 5.16b)

- Pattern Two consists of "inward-looking" and continuous integration core, not connected to the outside of the system (see fig. 5.17, 5.17a, 5.17b).

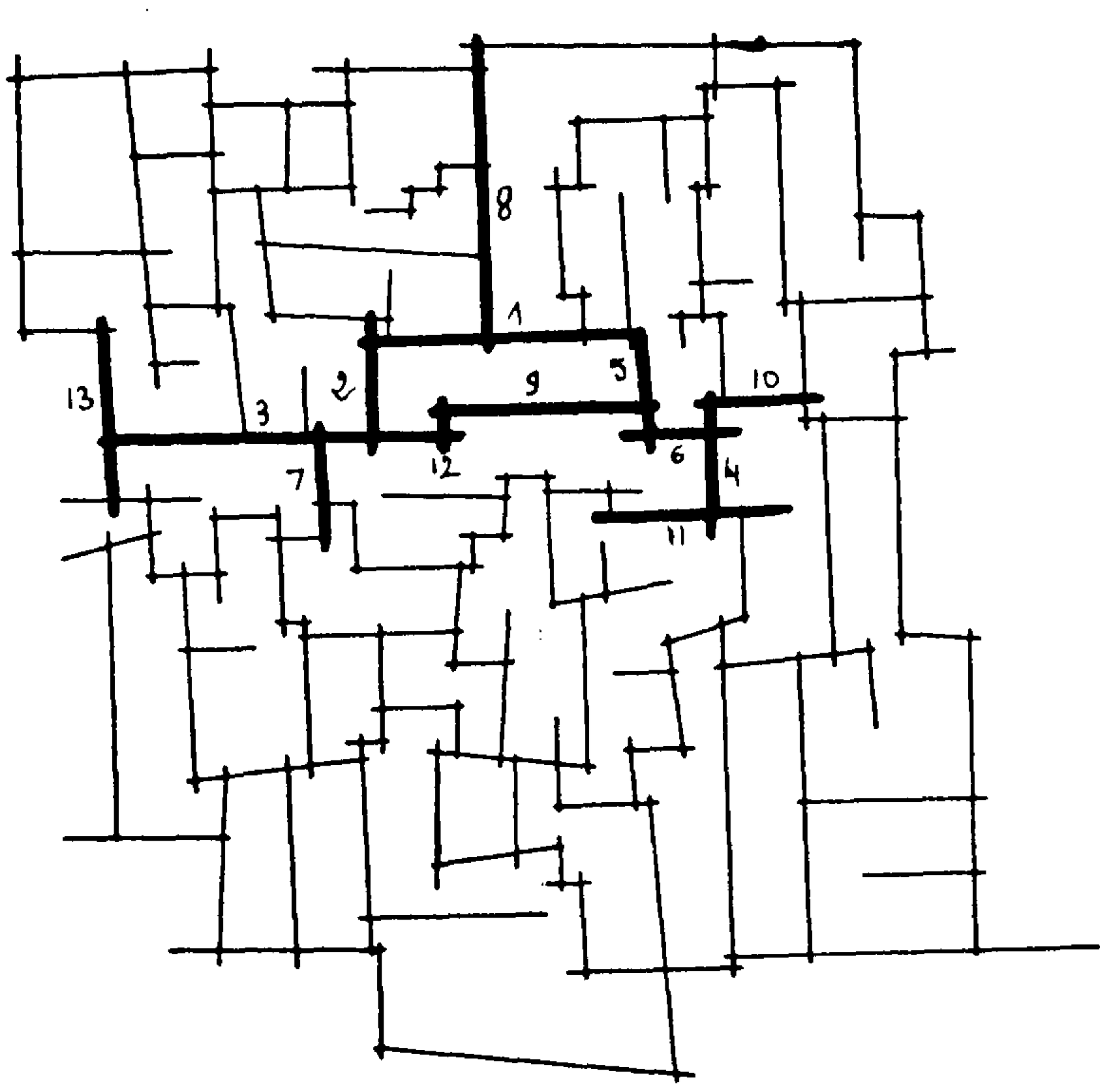
- Pattern Three includes systems with integration cores that are mainly constituted by peripheral lines connected to some internal lines forming a tree-like pattern on the edge of the morphology (see fig. 5.18, 5.18a, 5.18b).

- Pattern Four includes systems with integration cores of a fragmented nature with lines dispersed all over the surface (see fig. 5.19).

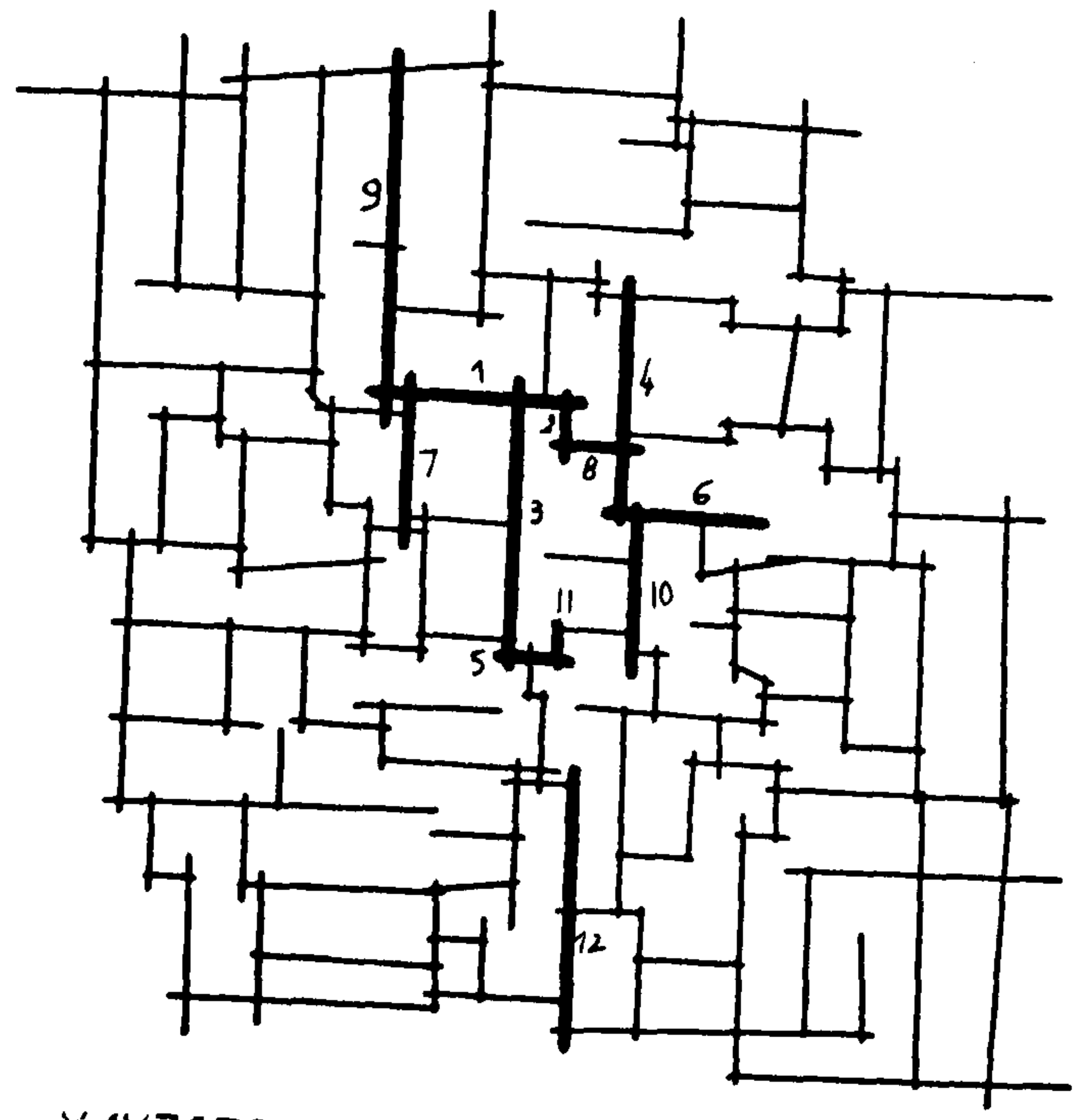
	PATTERN 1	PATTERN 2	PATTERN 3	PATTERN 4
PX = 0	4	2	3	0
PX = 0.4	5	4	0	0
PX = 0.6	1	7	1	0
PY = 0	1	5	1	2
PY = 0.6	5	4	0	0
PY = 0.7	2	2	5	0
PY = 0.8	3	1	5	0
PS = 0.2	1	1	1	5
PS = 0.4	3	4	0	1
PS = 0.8	5	4	0	0
% FOR SAMPLE	28.57	37.14	22.86	11.43

TABLE 5.9: CLASSIFICATION OF PATTERNS OF INTEGRATION CORES, ACCORDING TO THE GENERATIVE RULES.

Table 5.9 gives a summary of the four different patterns of integration found in the simulated systems and in relation to the three generative rules: the x clus-



X4Y705S8



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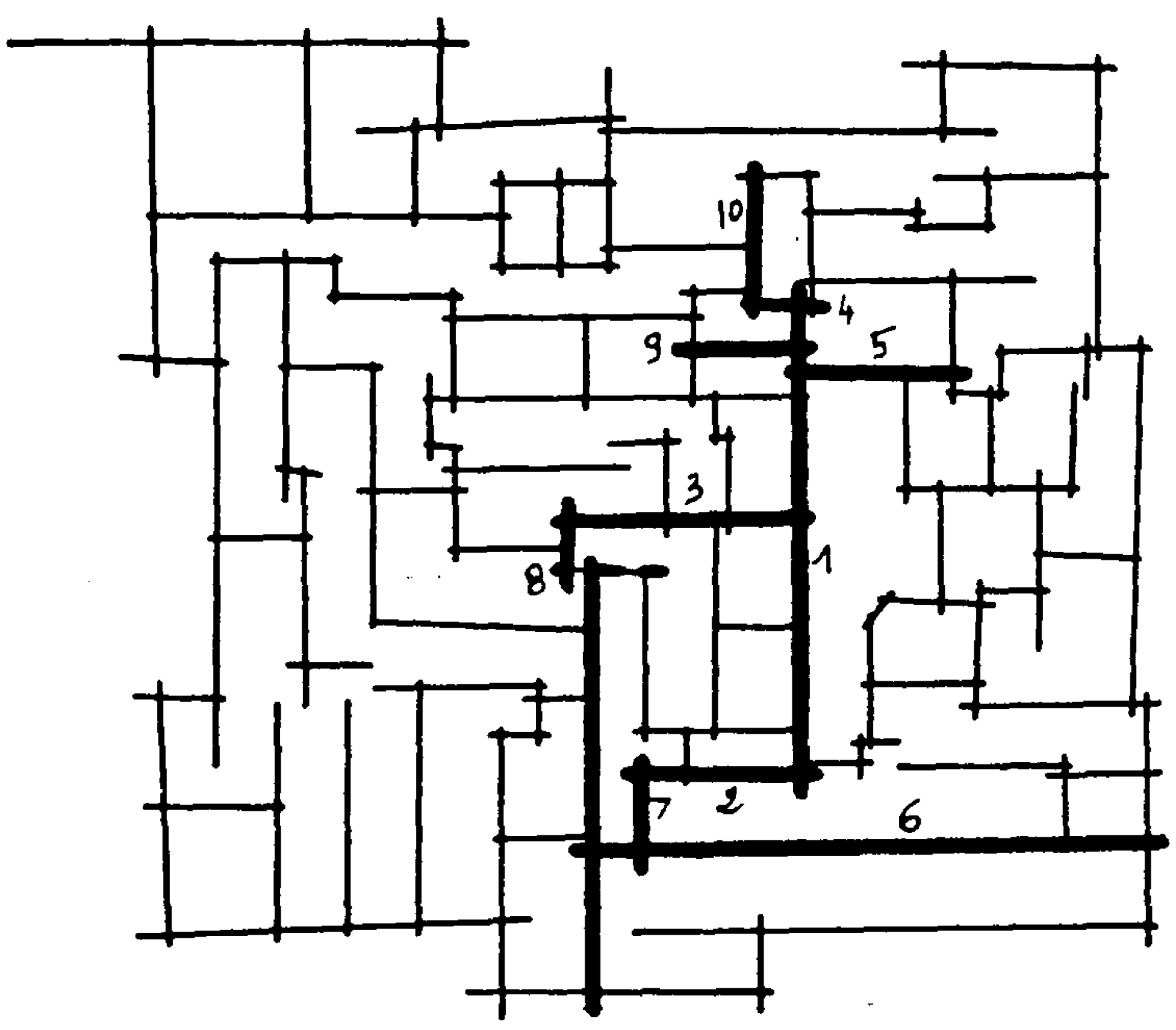

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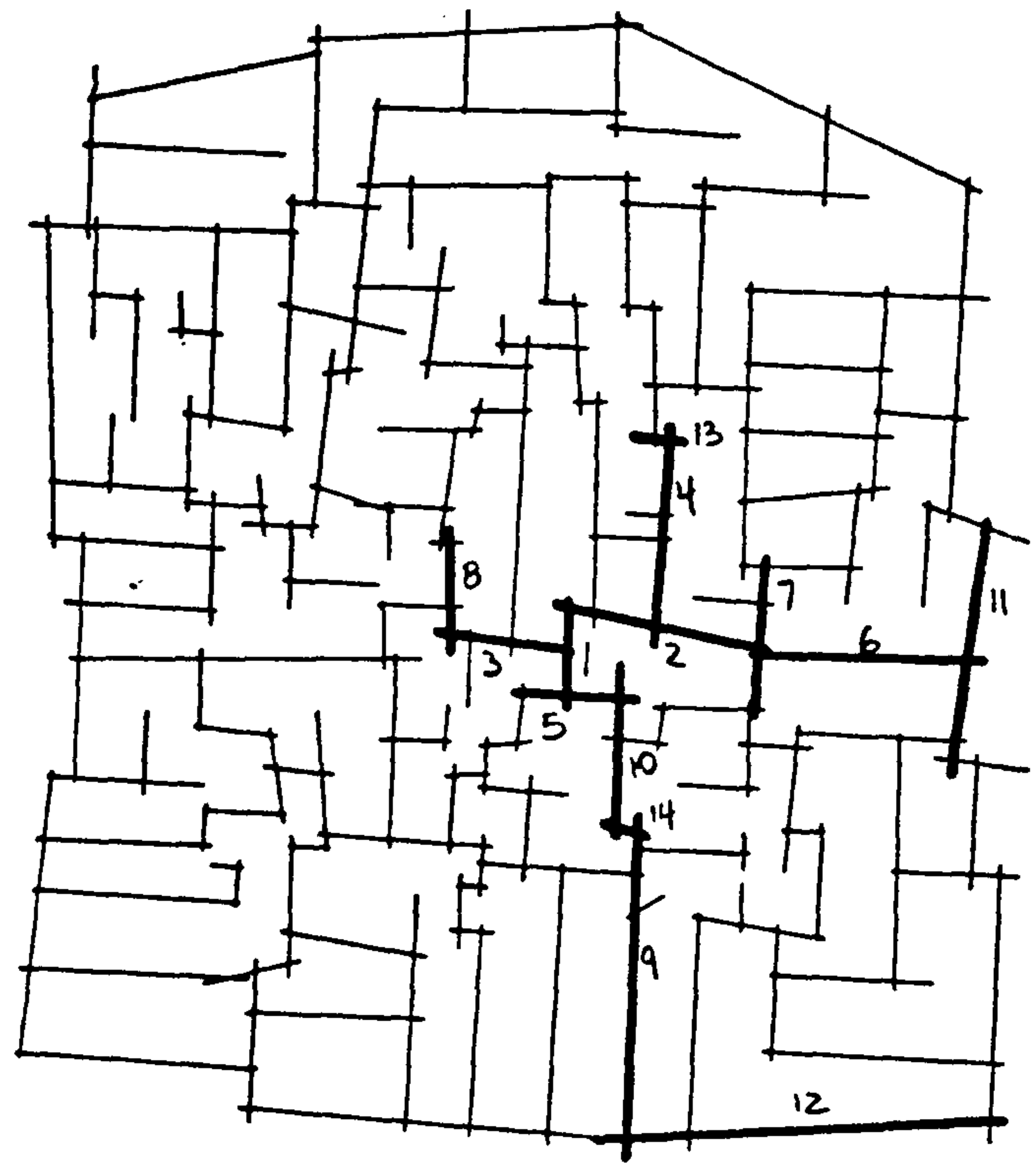
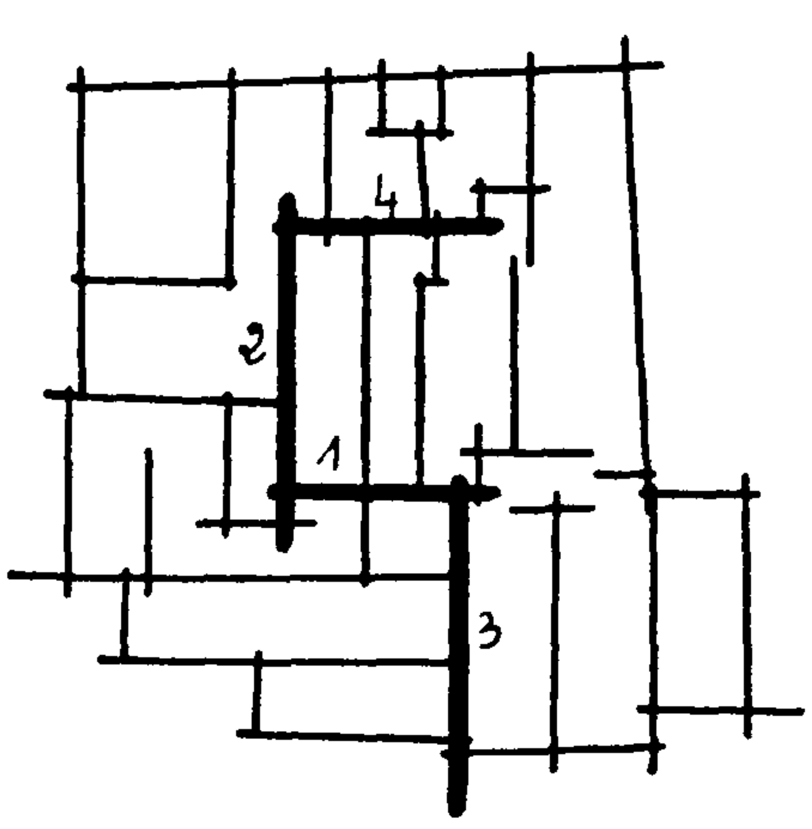
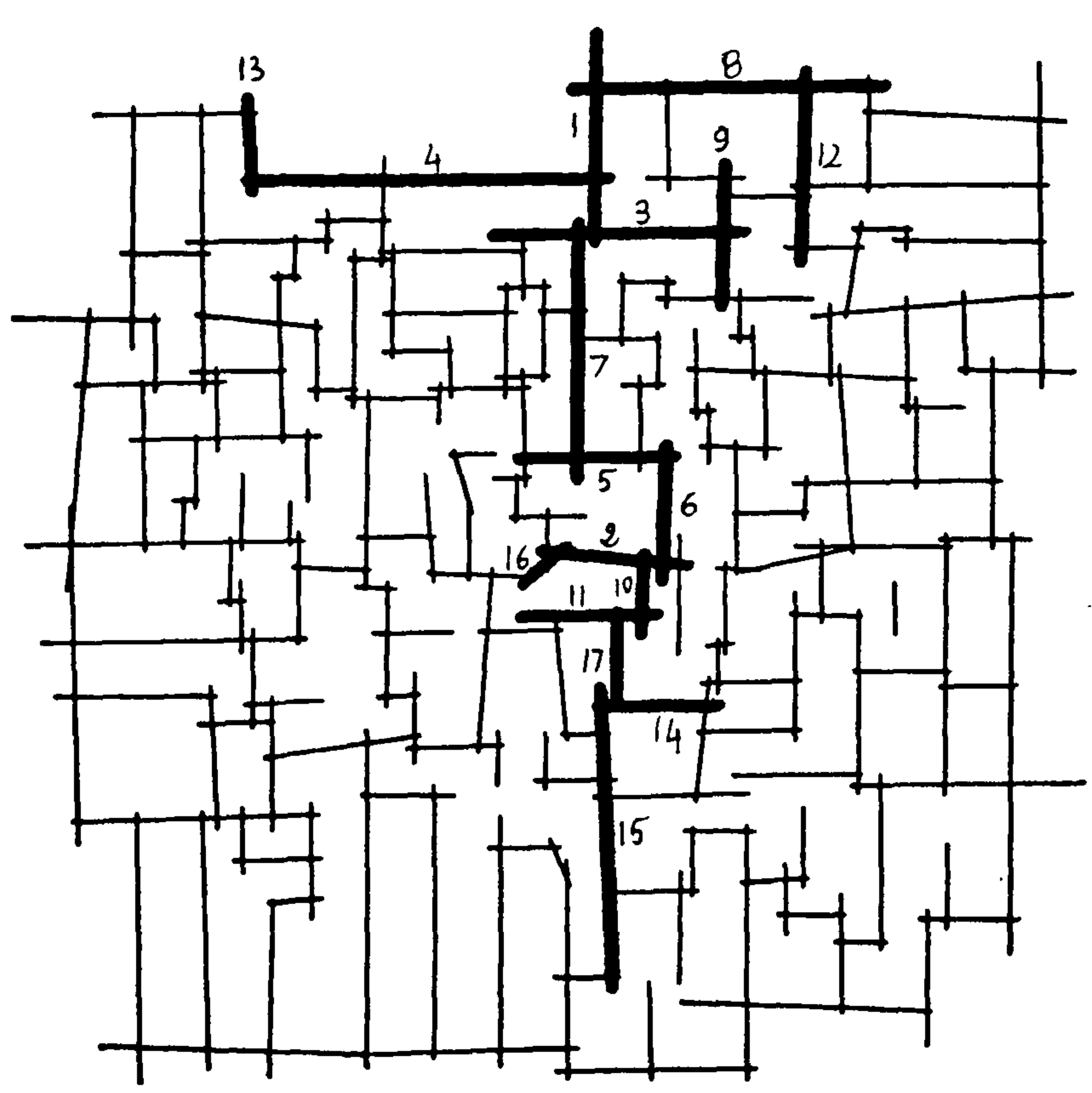


X4Y605S8

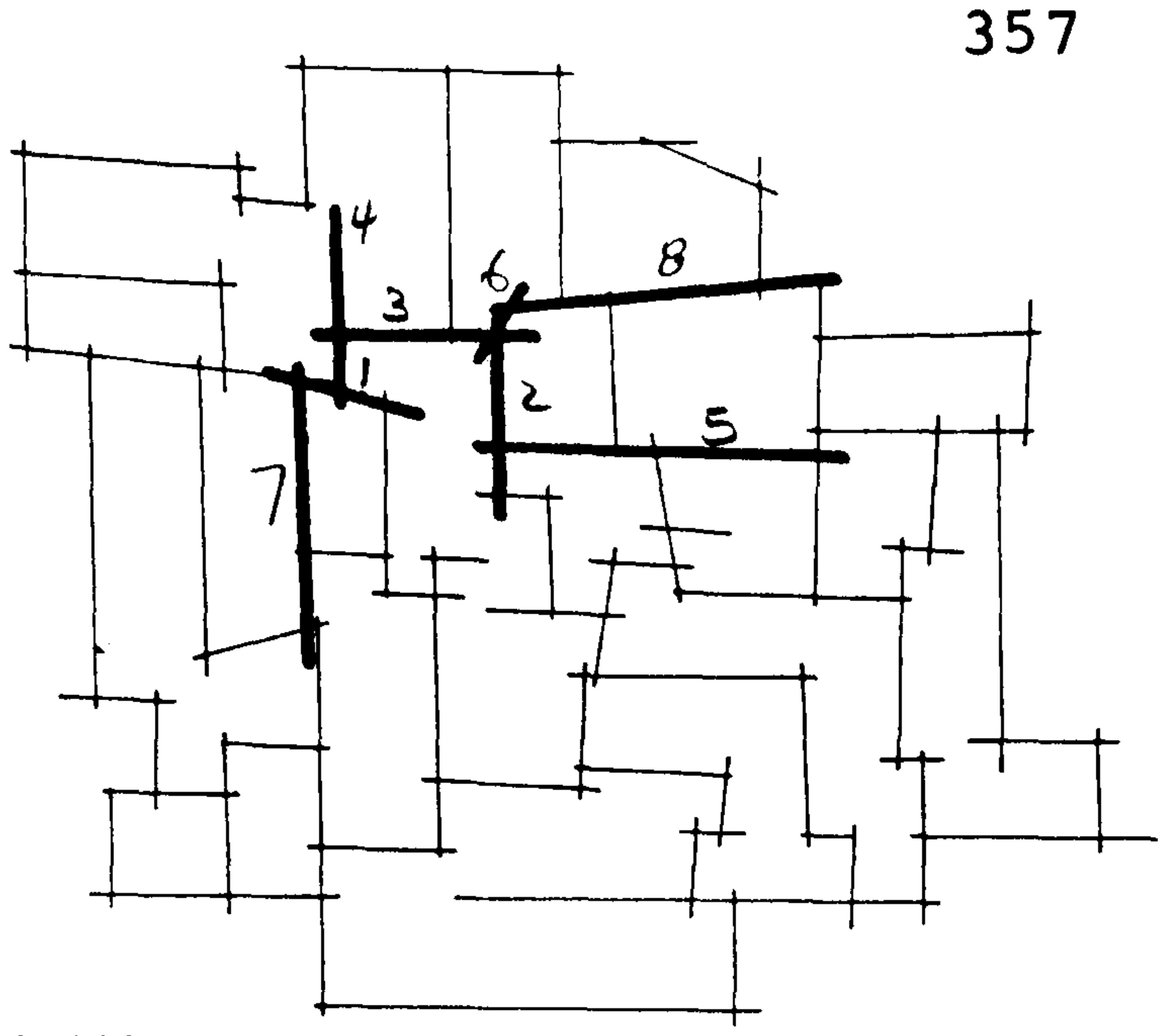


X4Y805S8

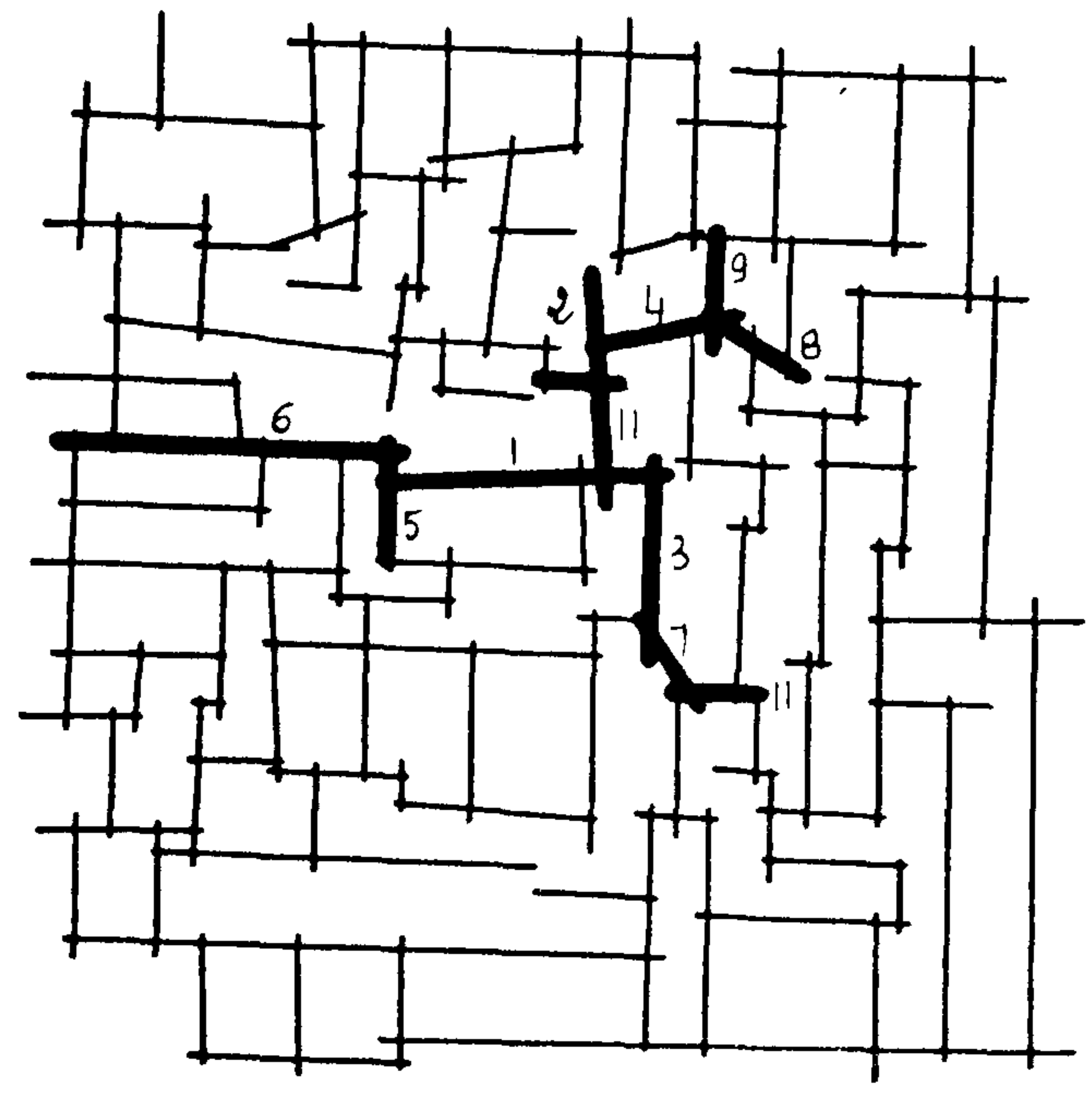


X4Y605S8

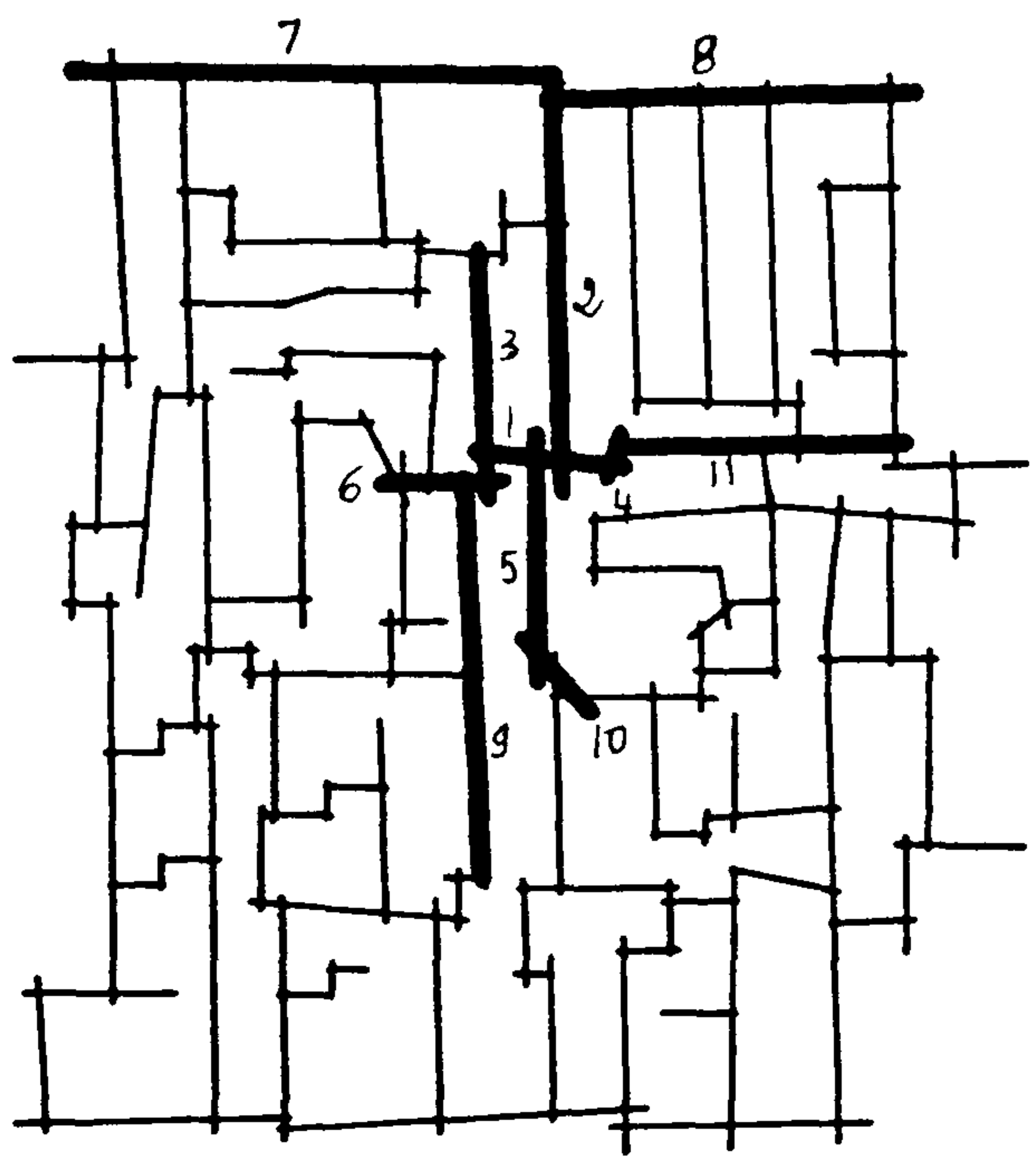
FIG. 5.16 : INTEGRATION CORES
<u>PATTERN ONE</u>



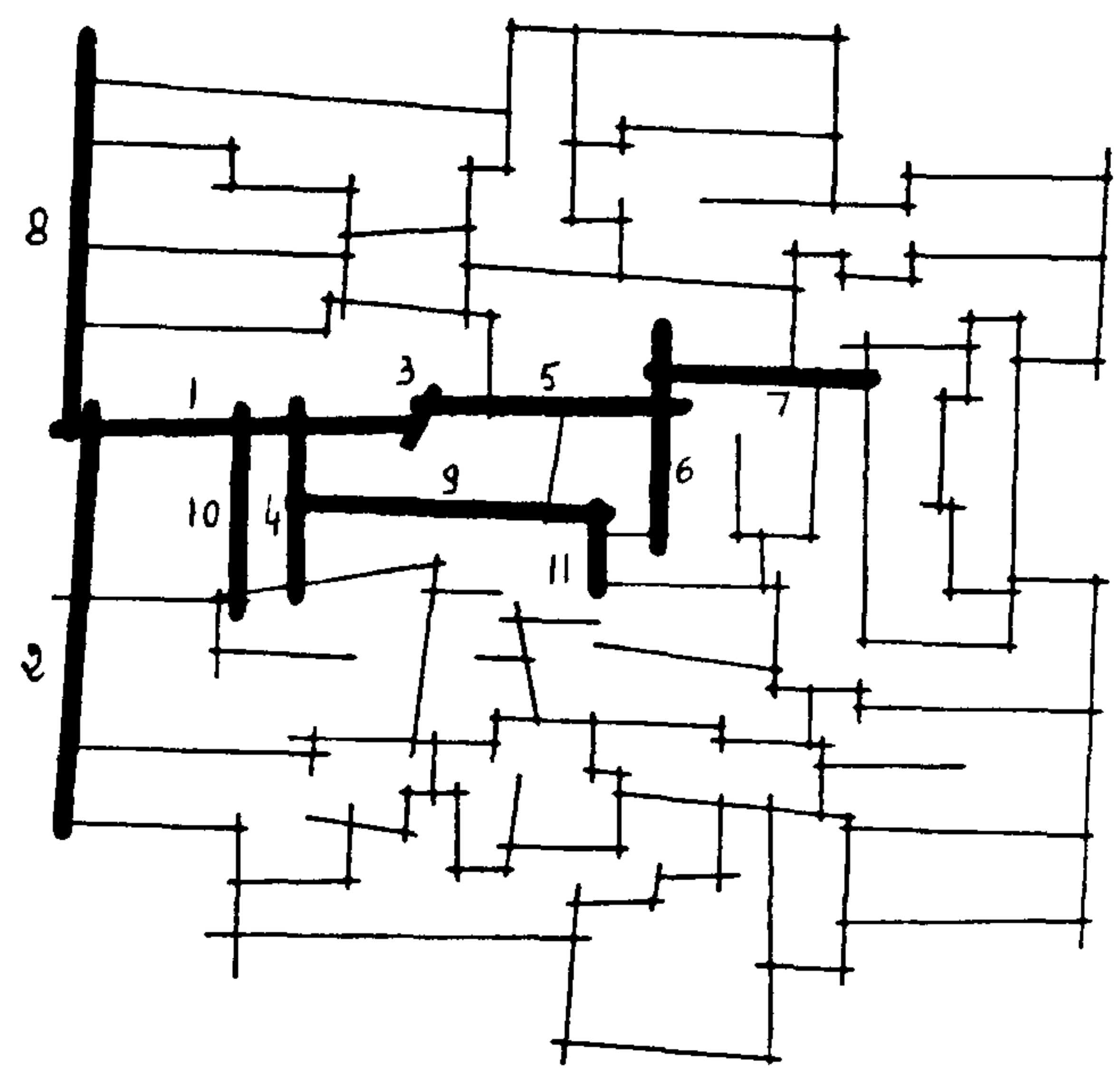
X4Y605S8



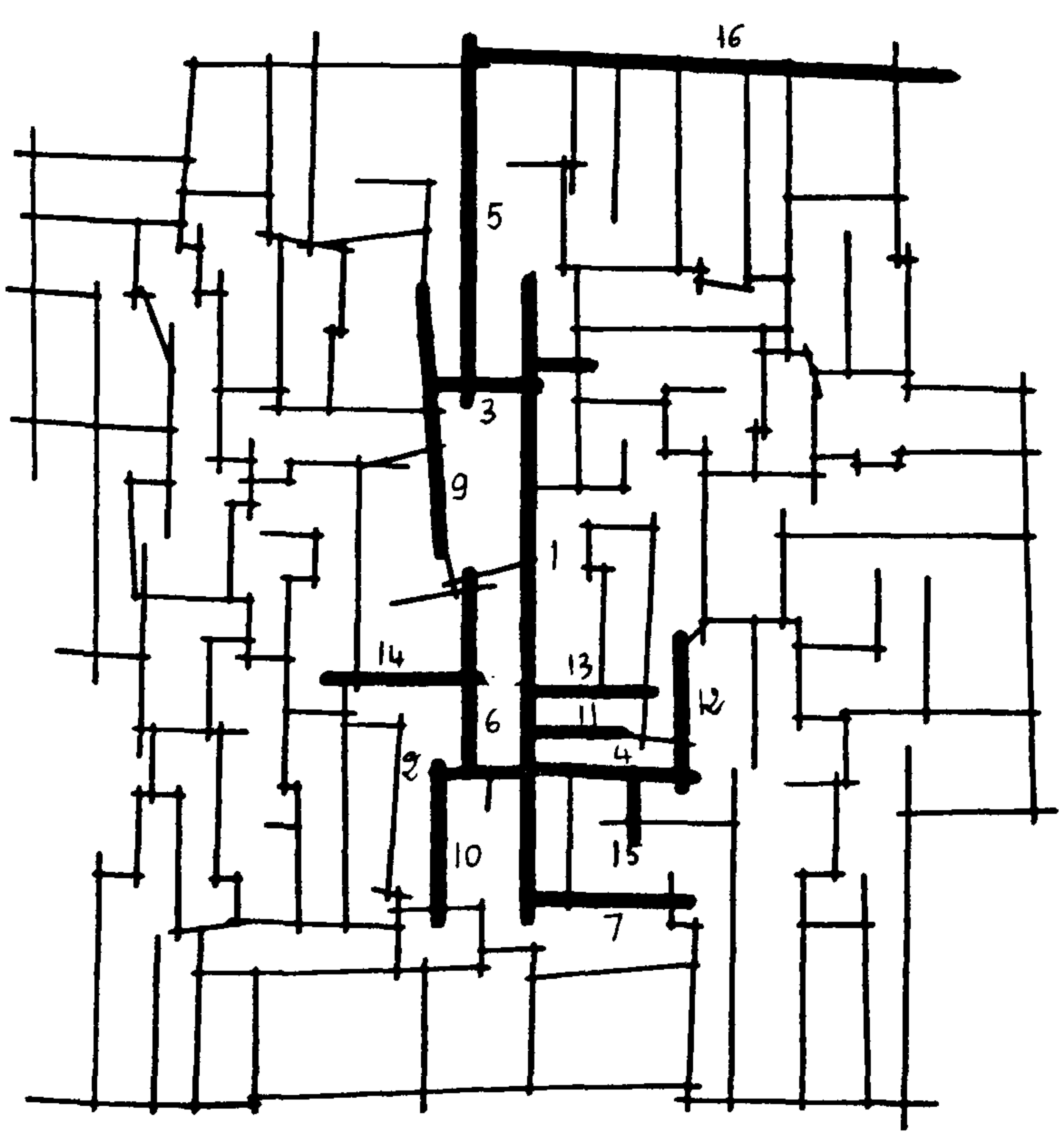
X4Y605S8



X0Y605S8



X0Y605S8



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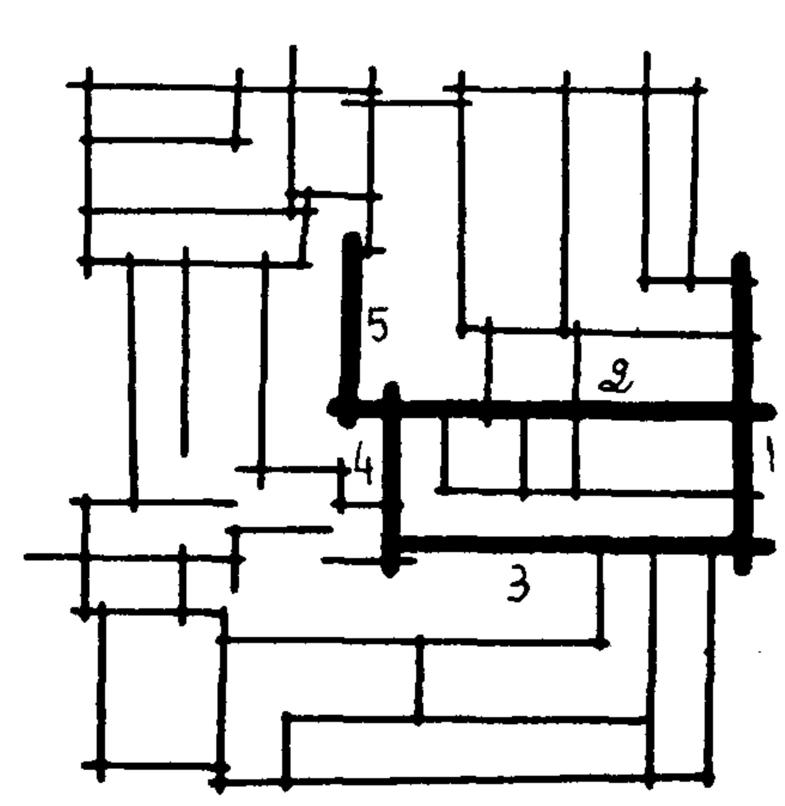
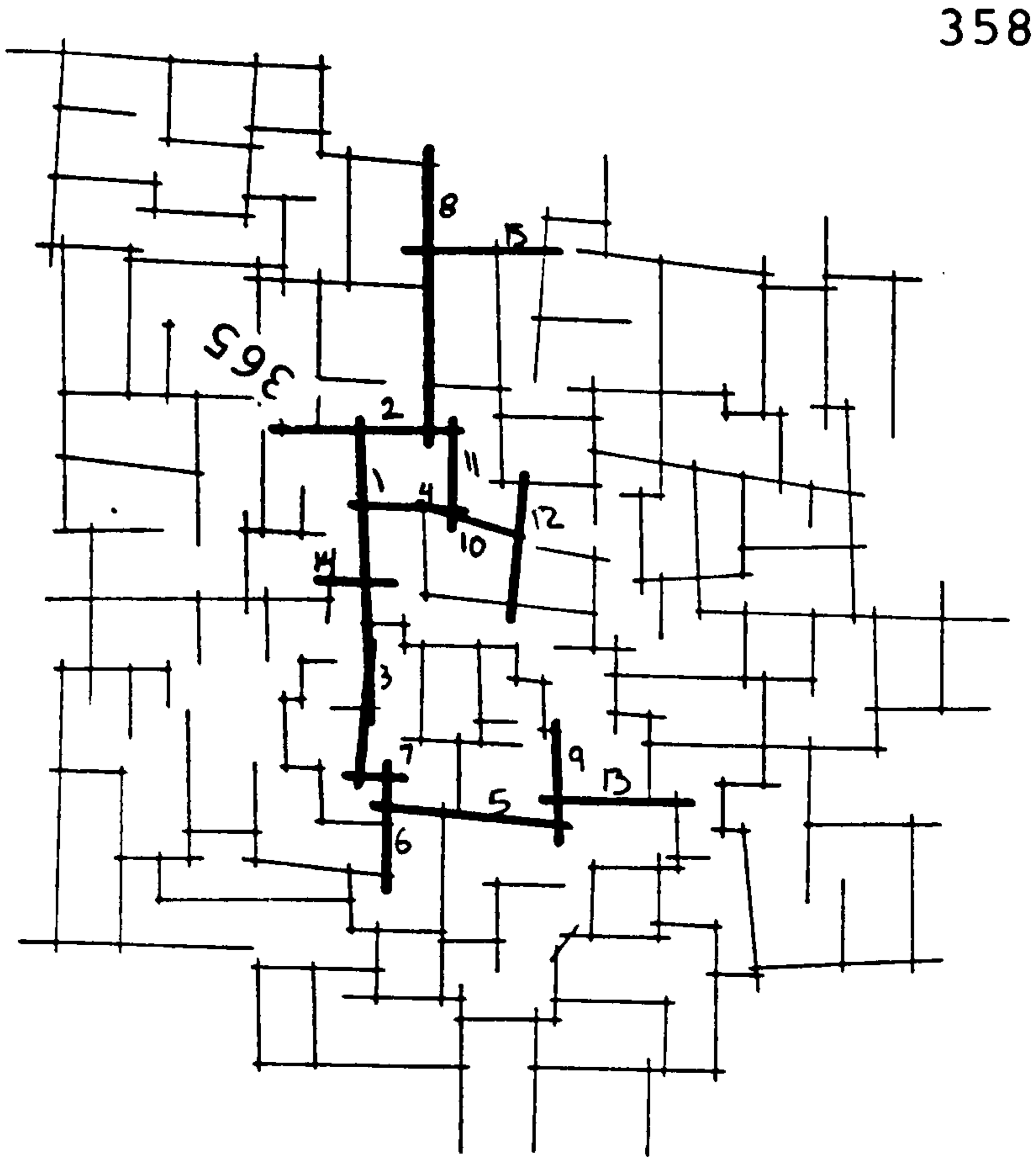


X0Y605S8

FIG. 5.16a: INTEGRATION CORES
PATTERN ONE



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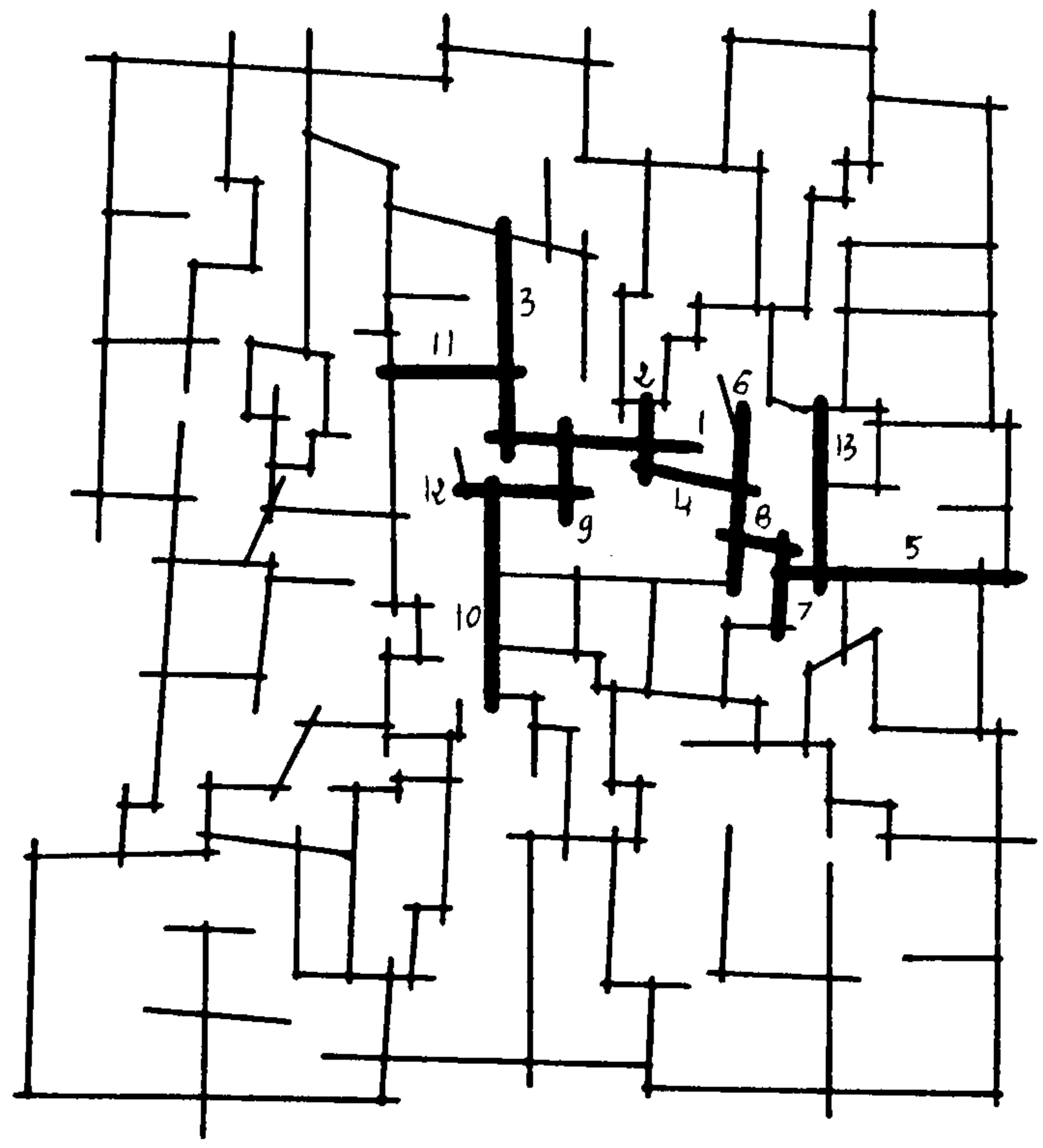

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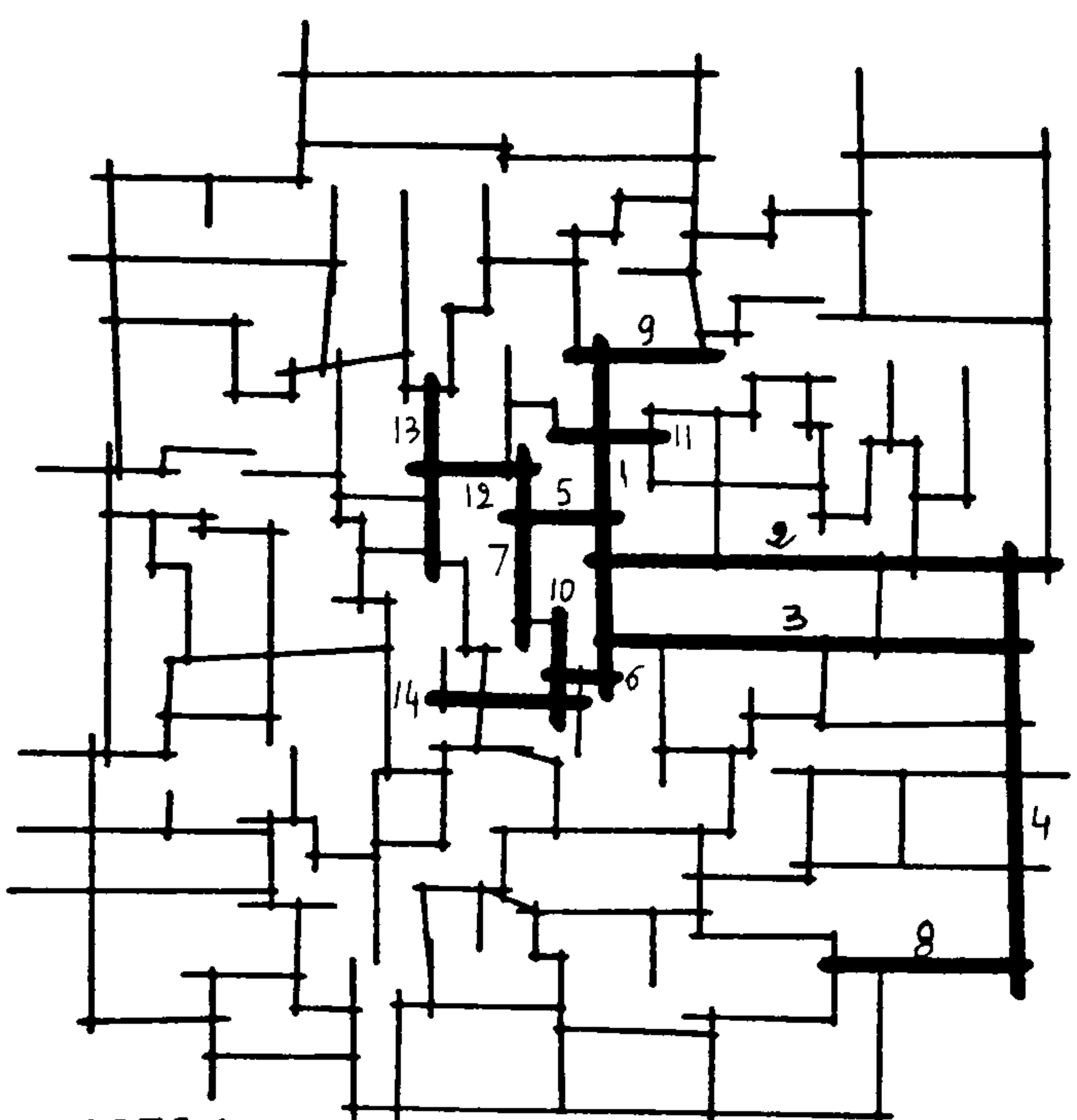

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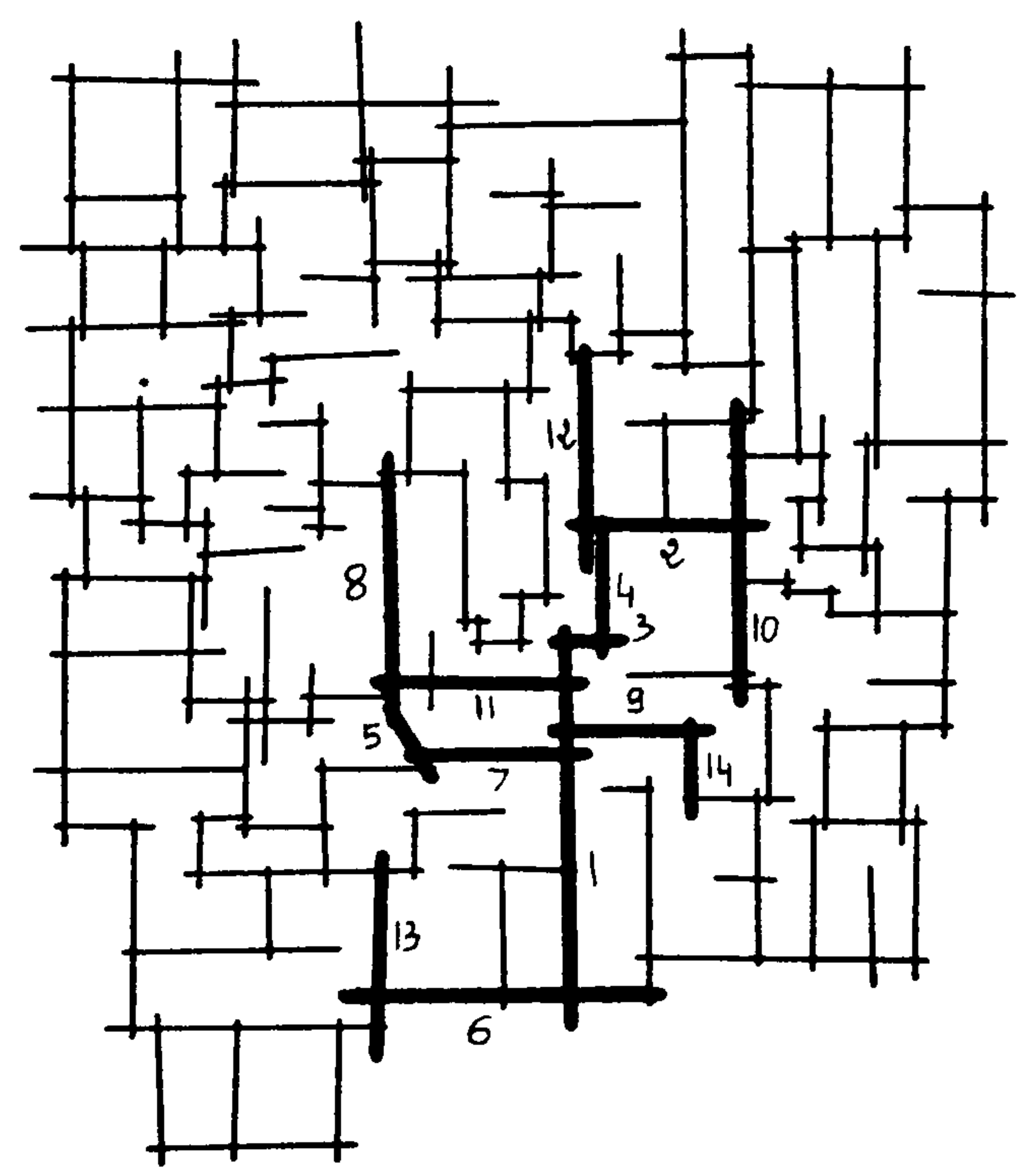

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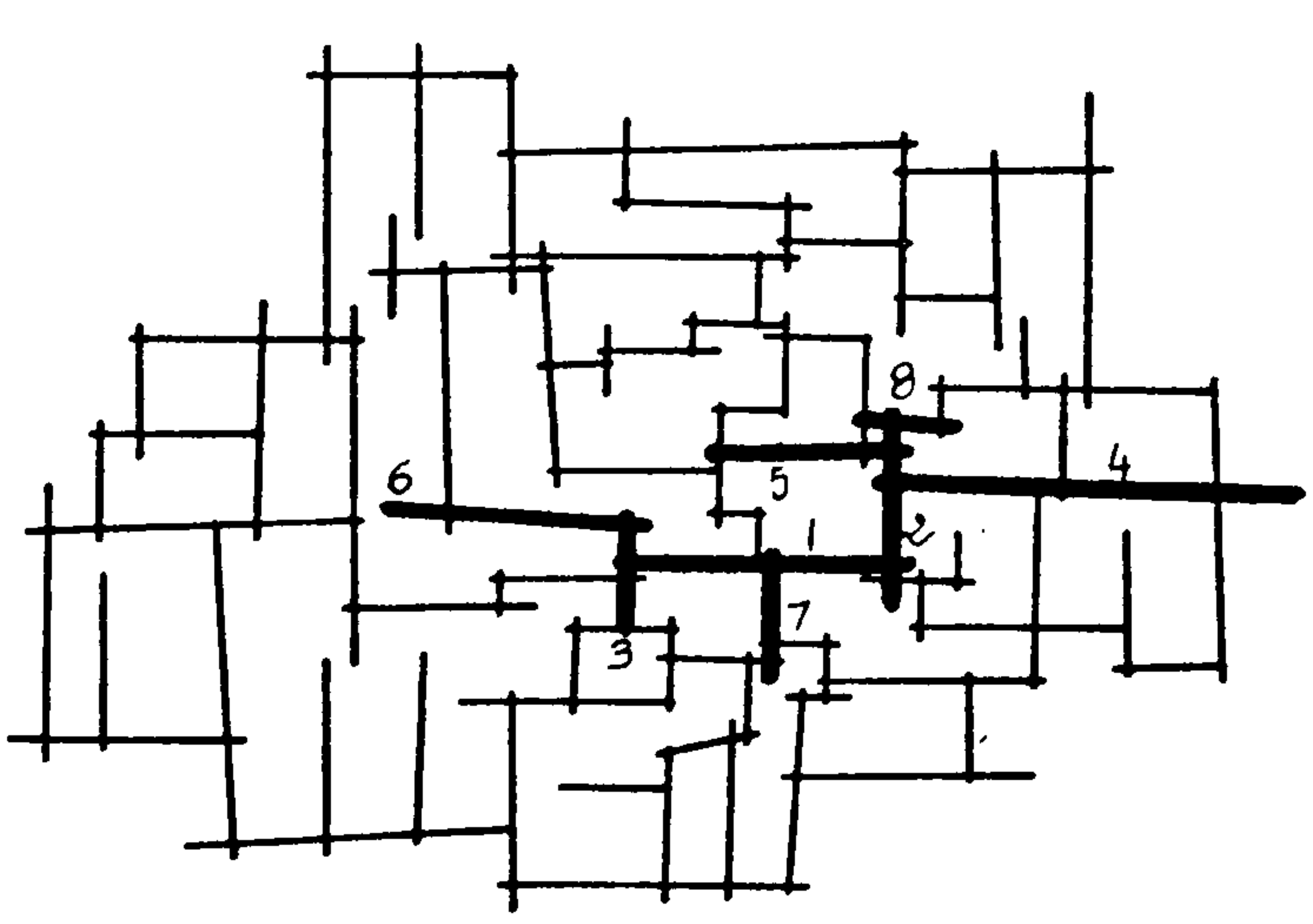

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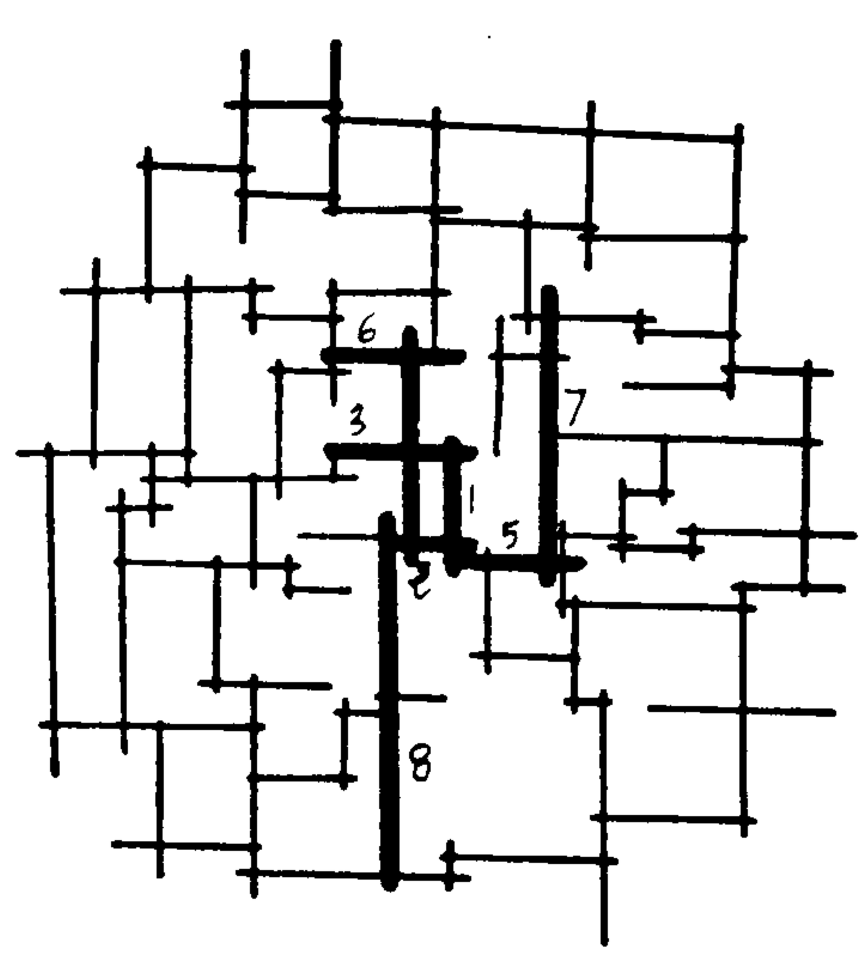


X4Y605S4

FIG. 5.16b : INTEGRATION CORES
<u>PATTERN ONE</u>

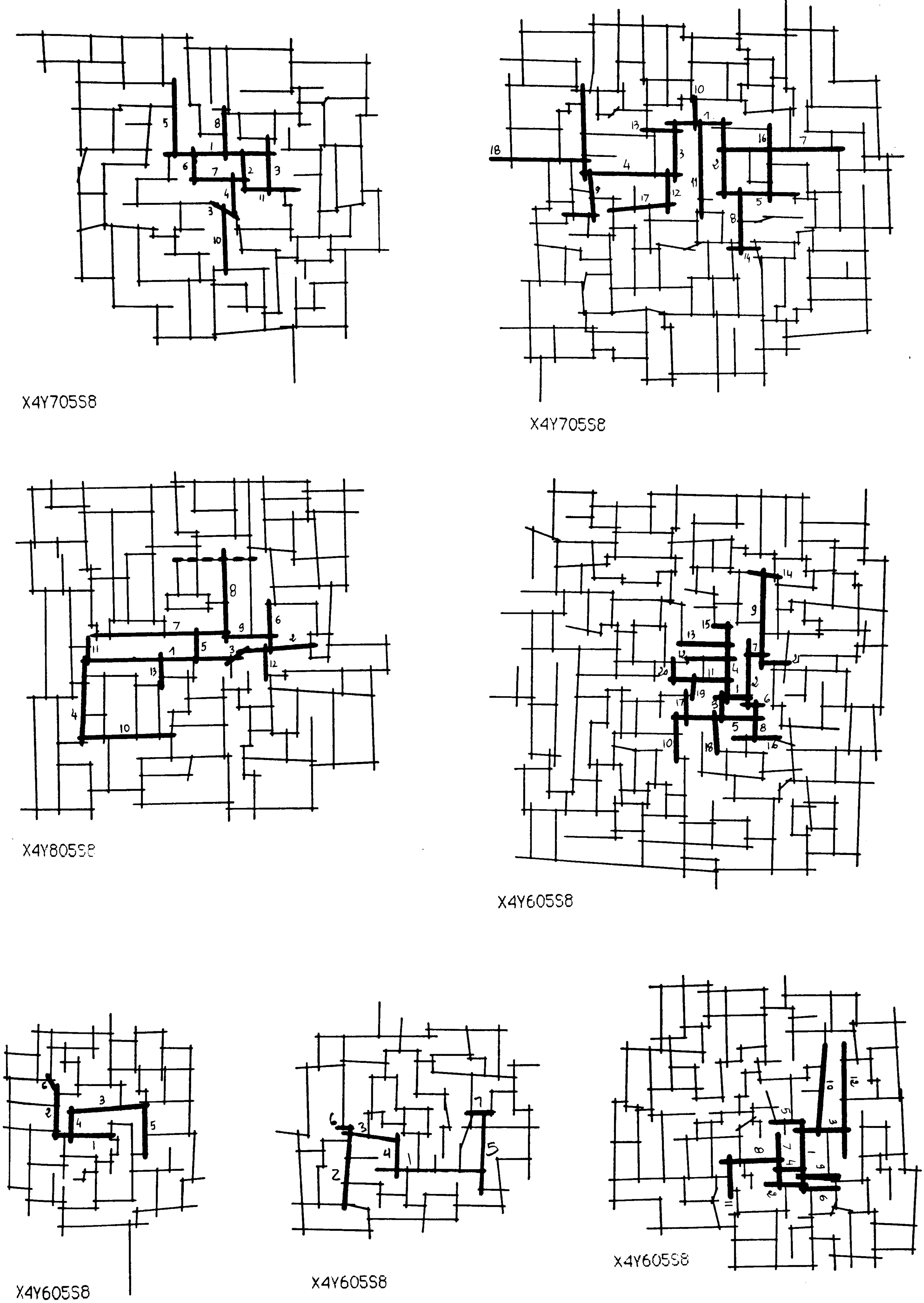
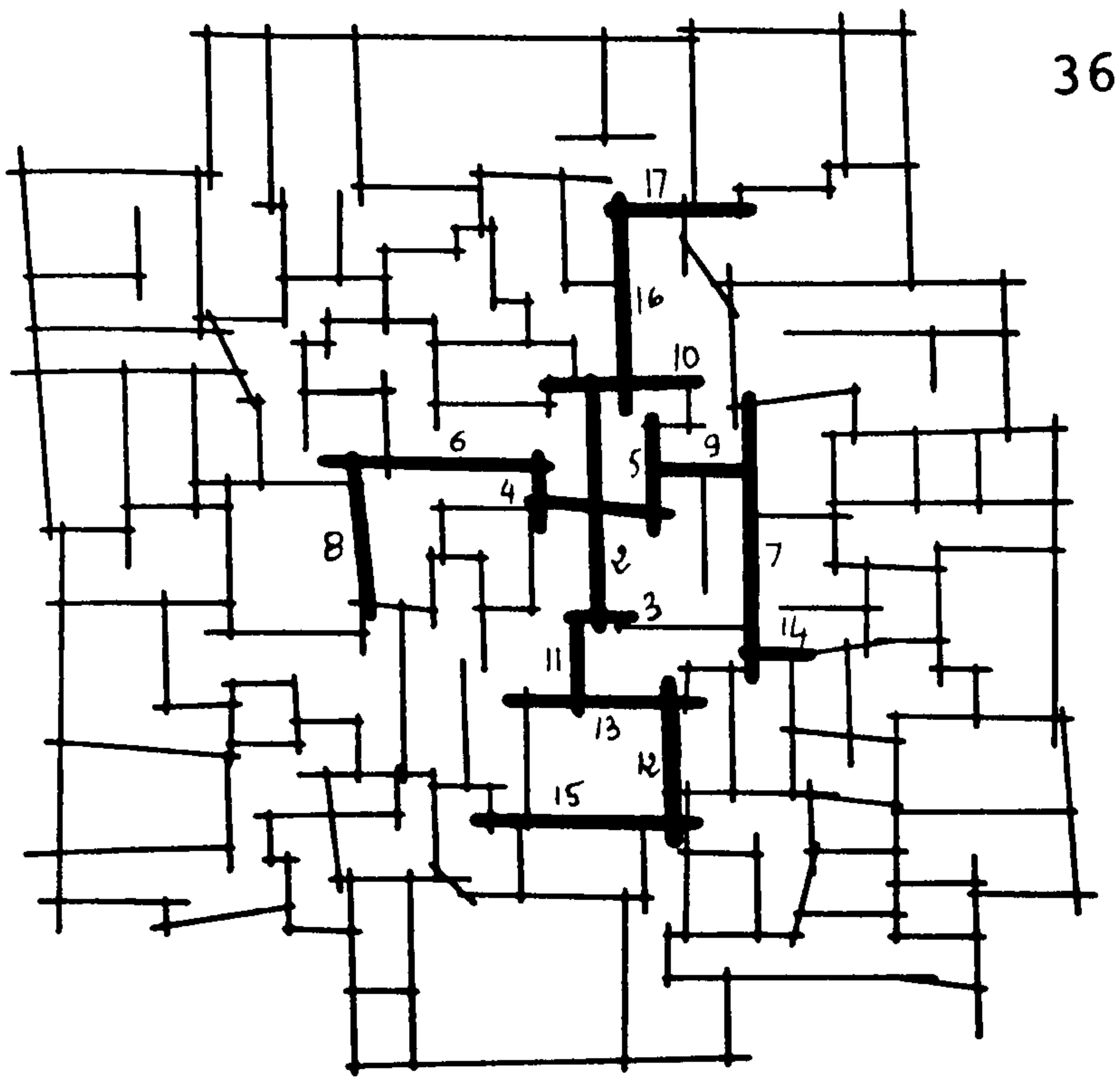


FIG. 5.17 : INTEGRATION CORES
PATTERN TWO



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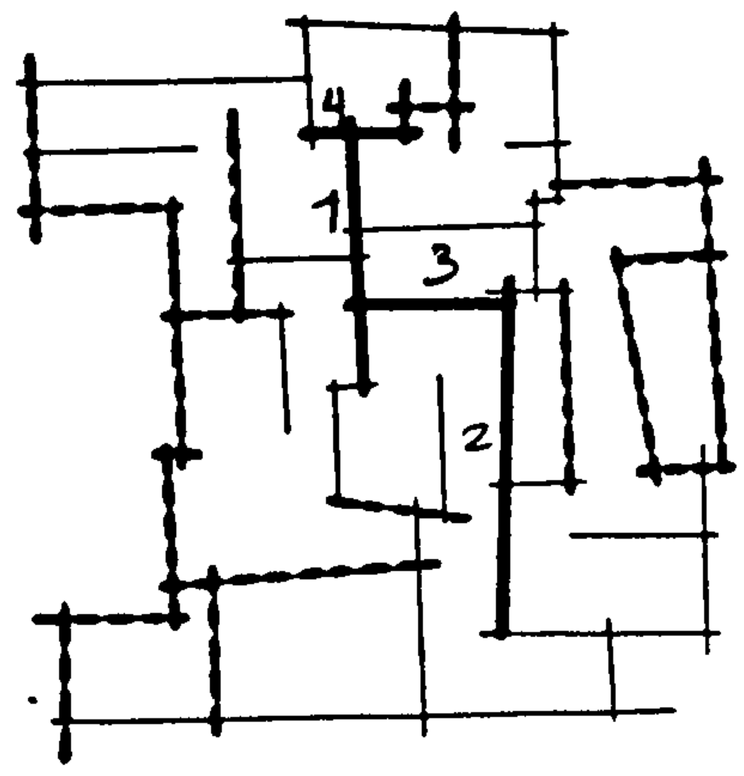

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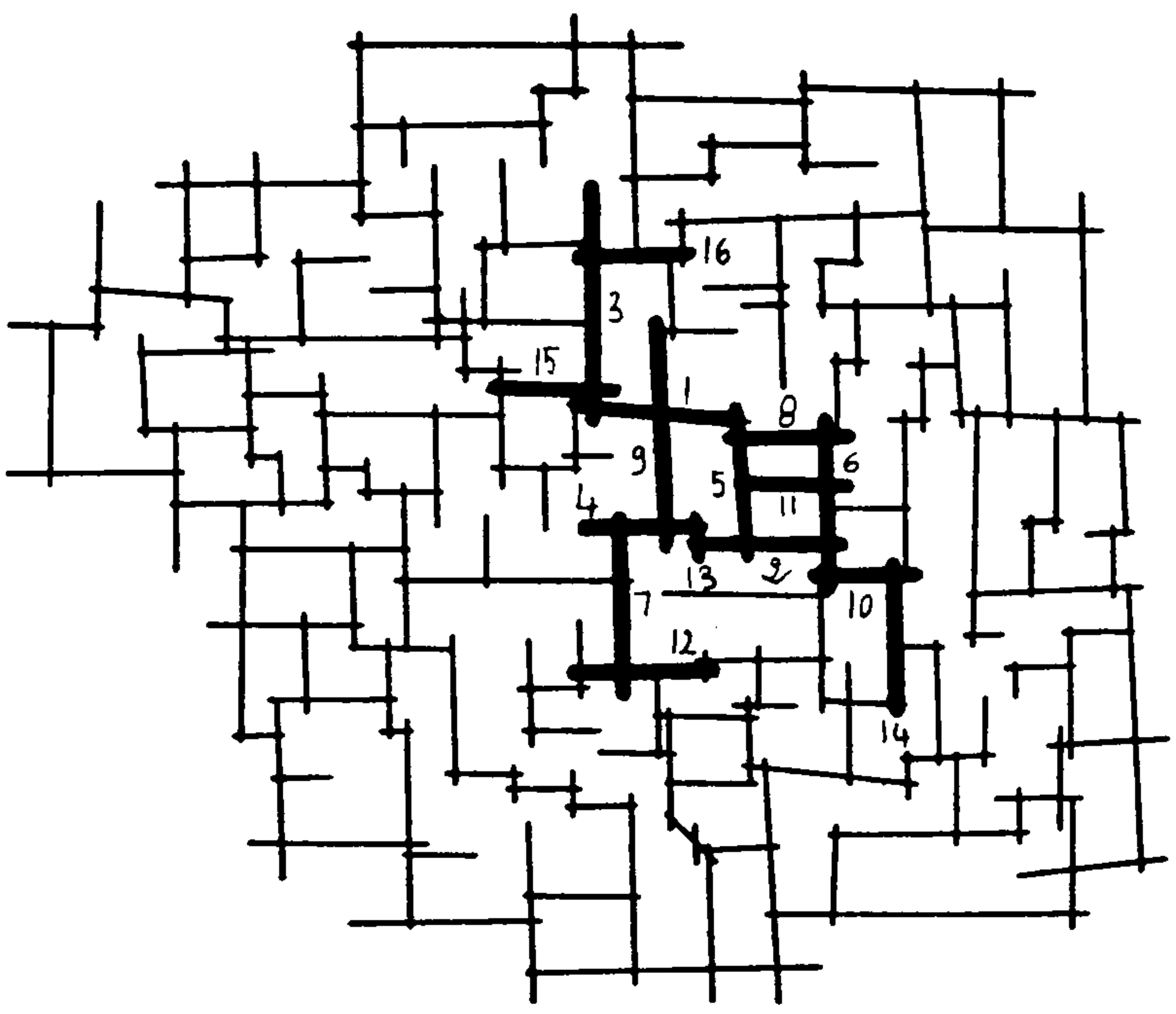

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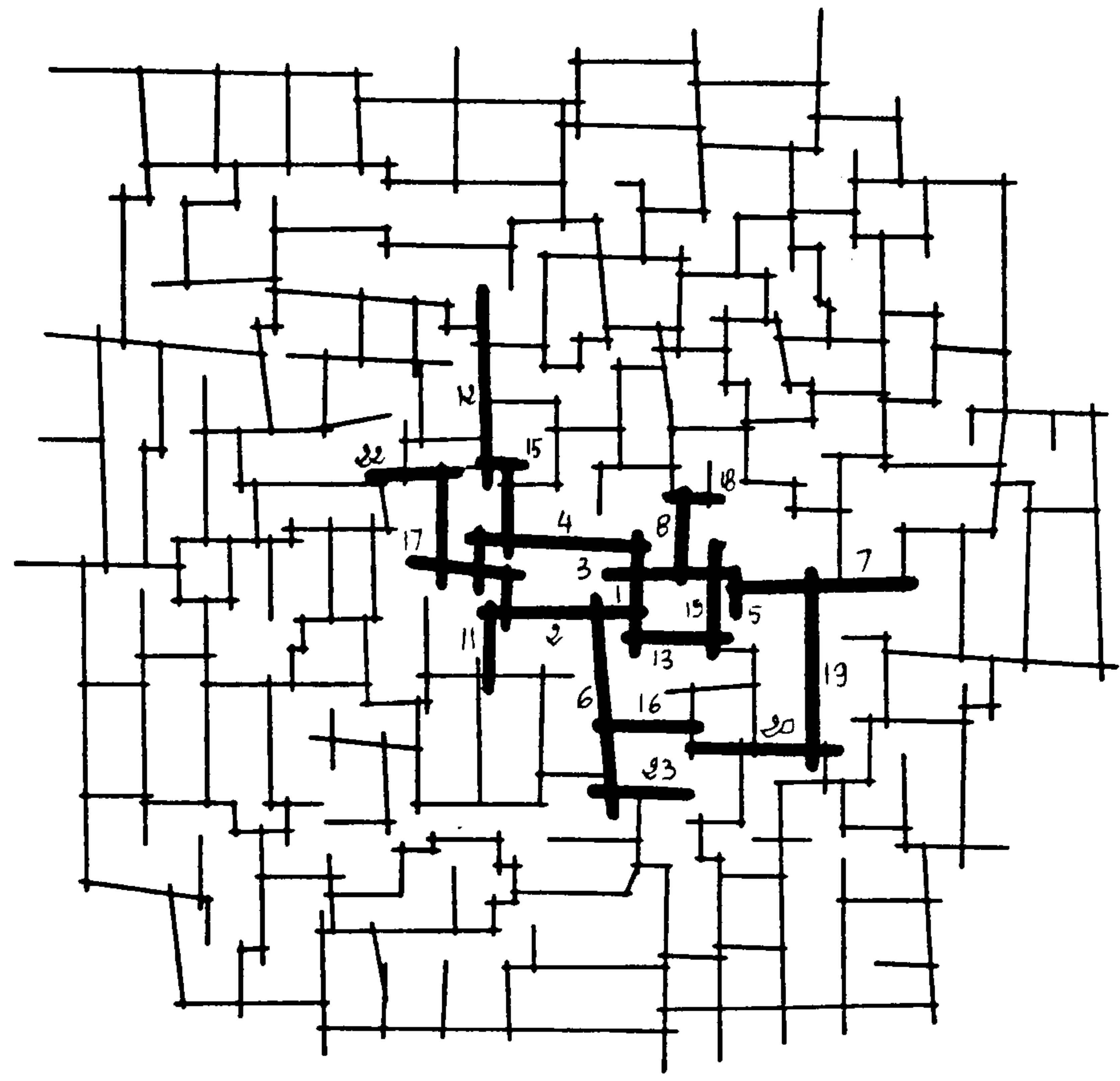

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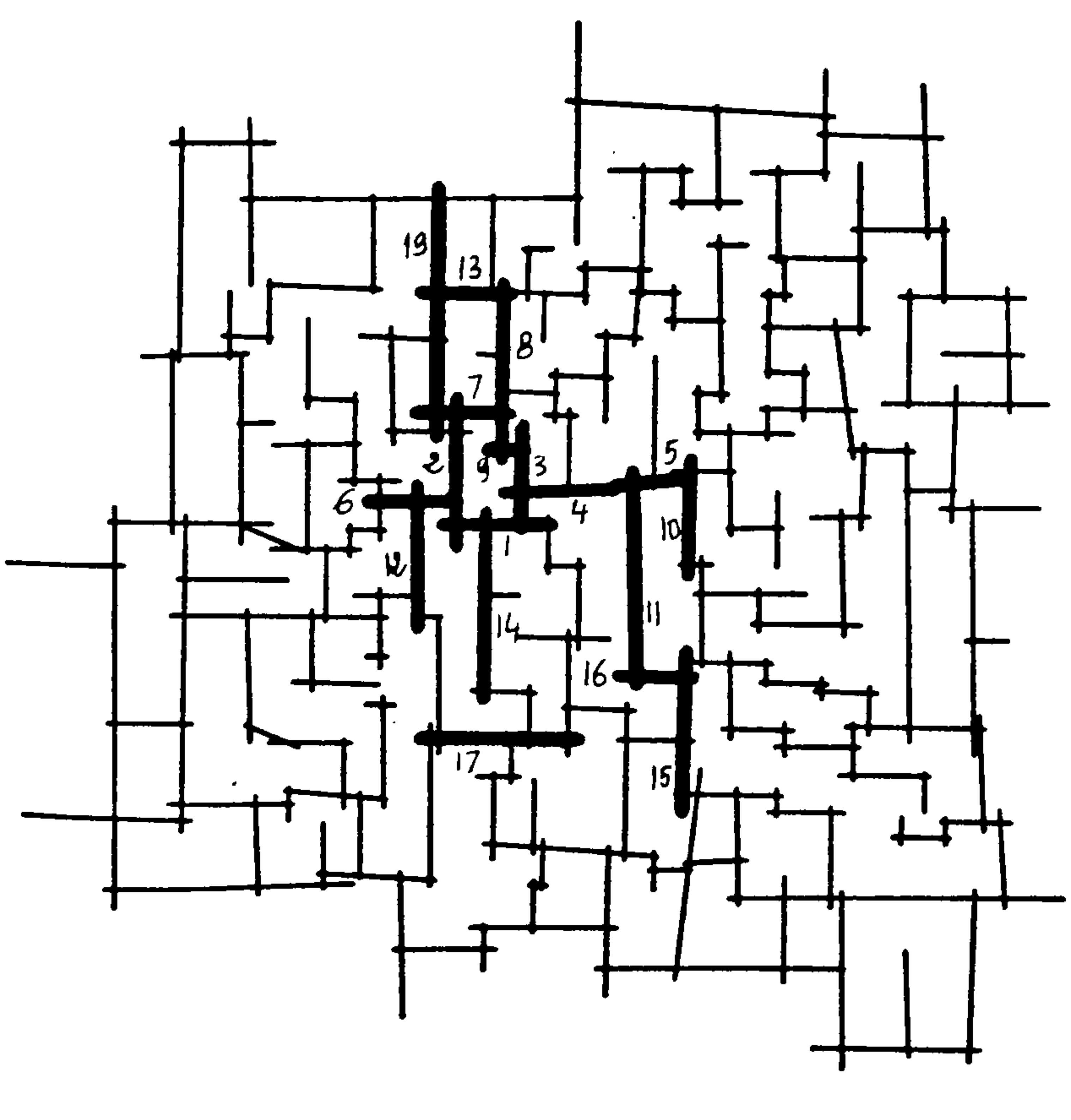

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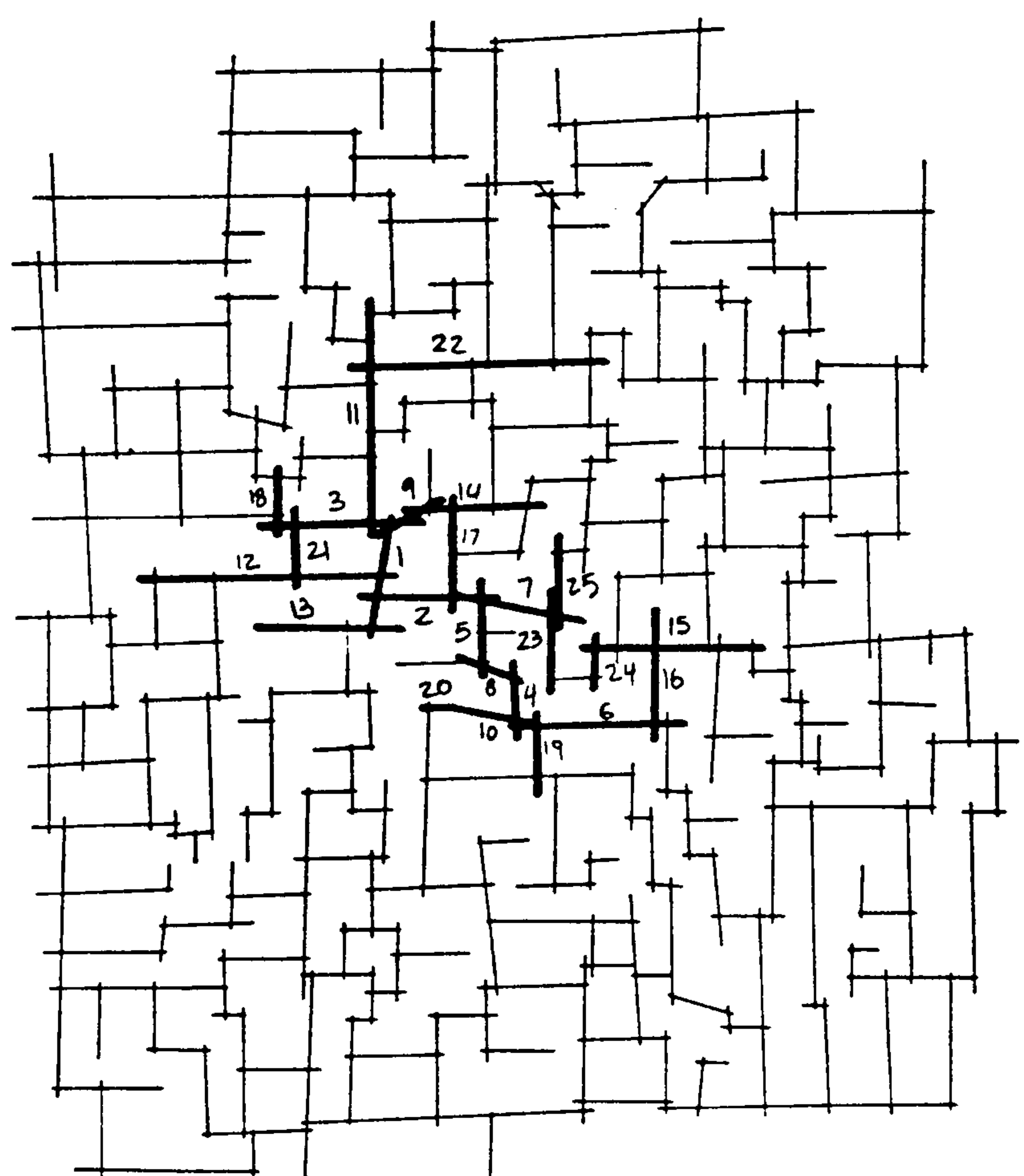
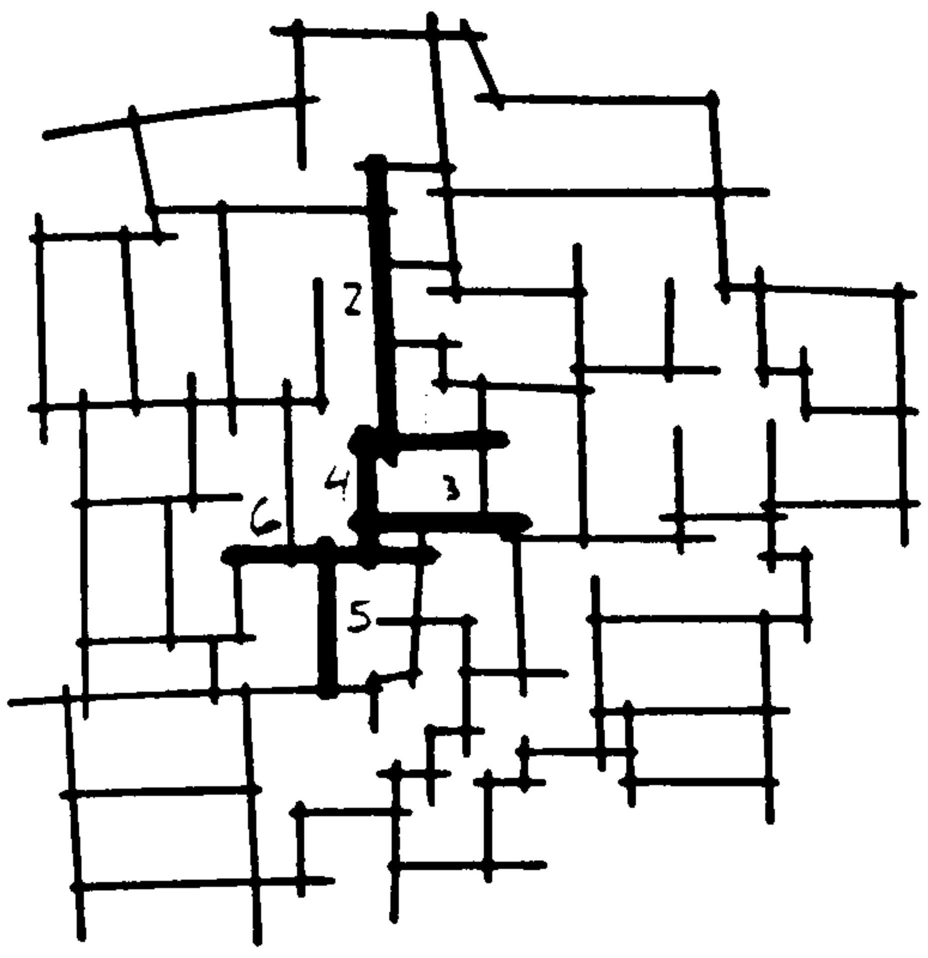


X6Y606S8

FIG. 5.17a : INTEGRATION CORES
PATTERN TWO



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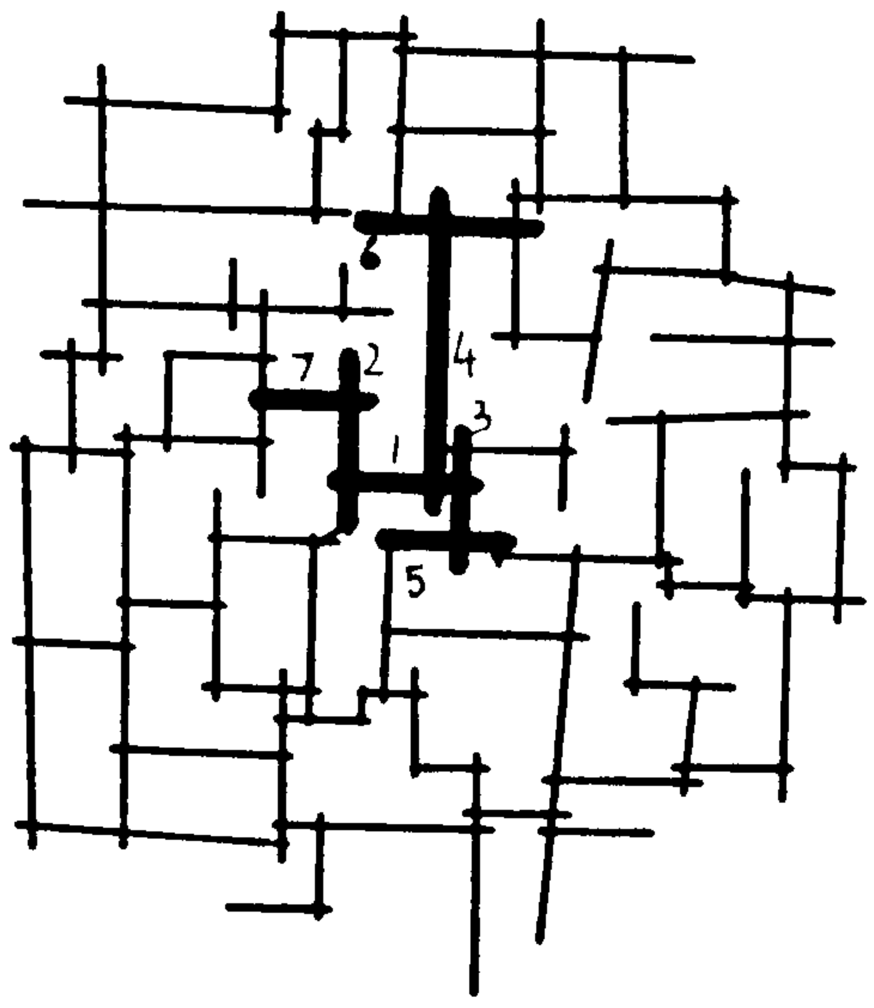

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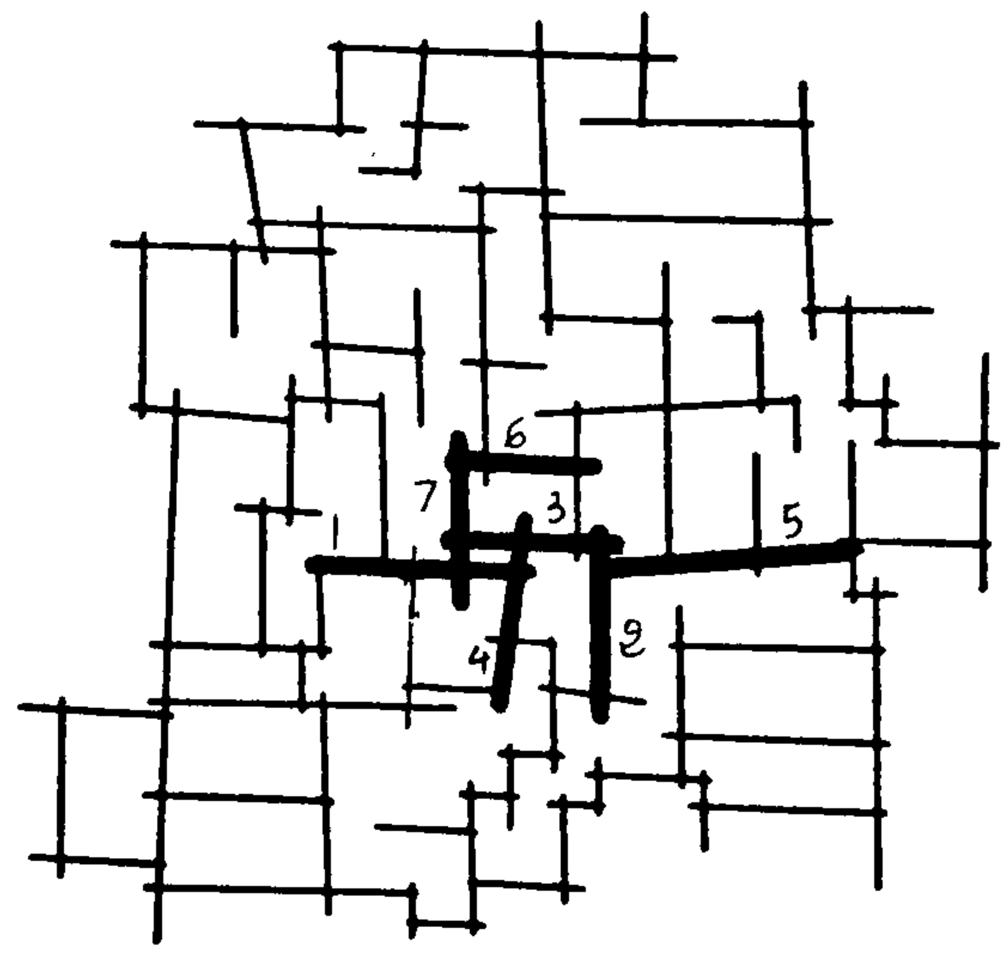

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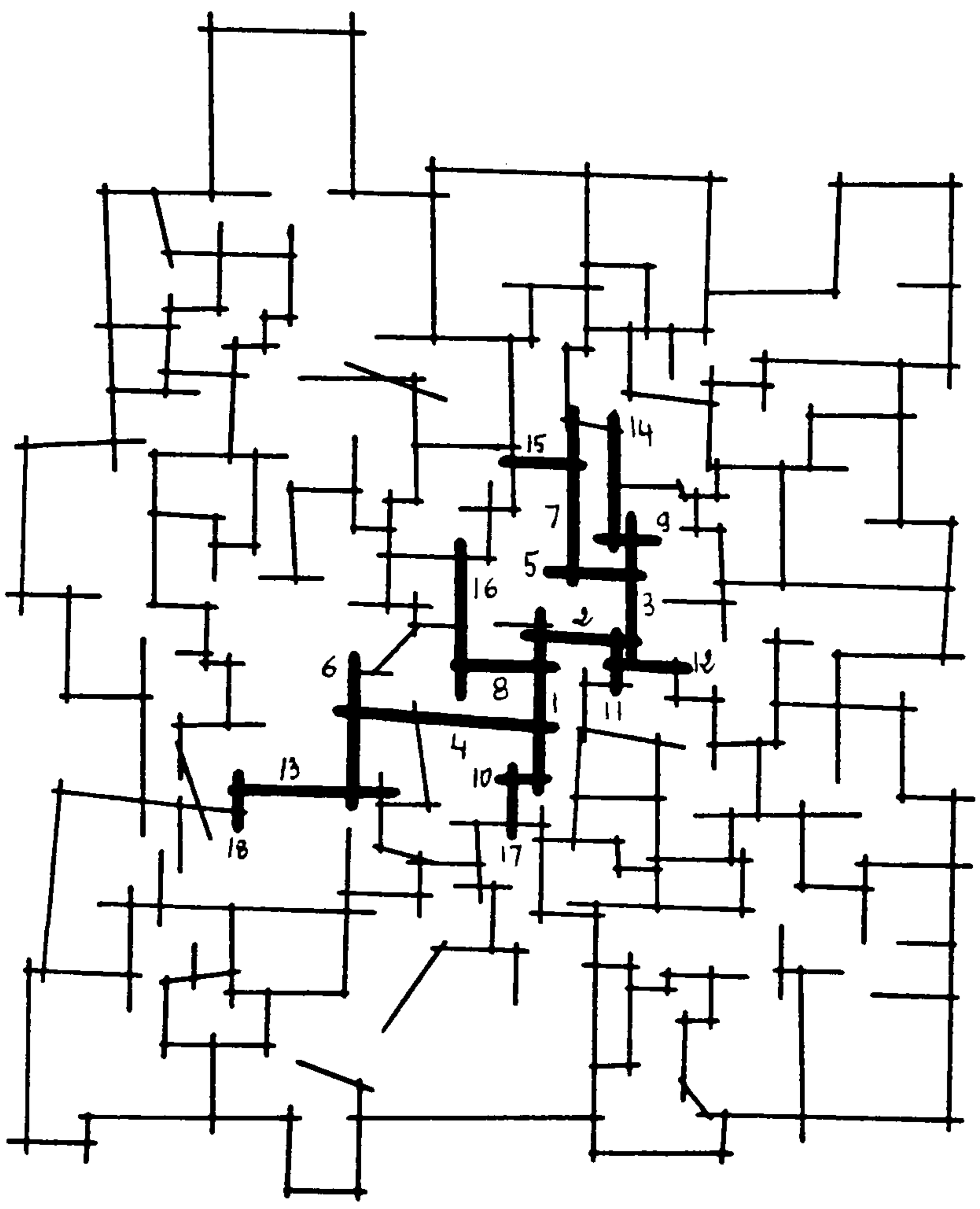

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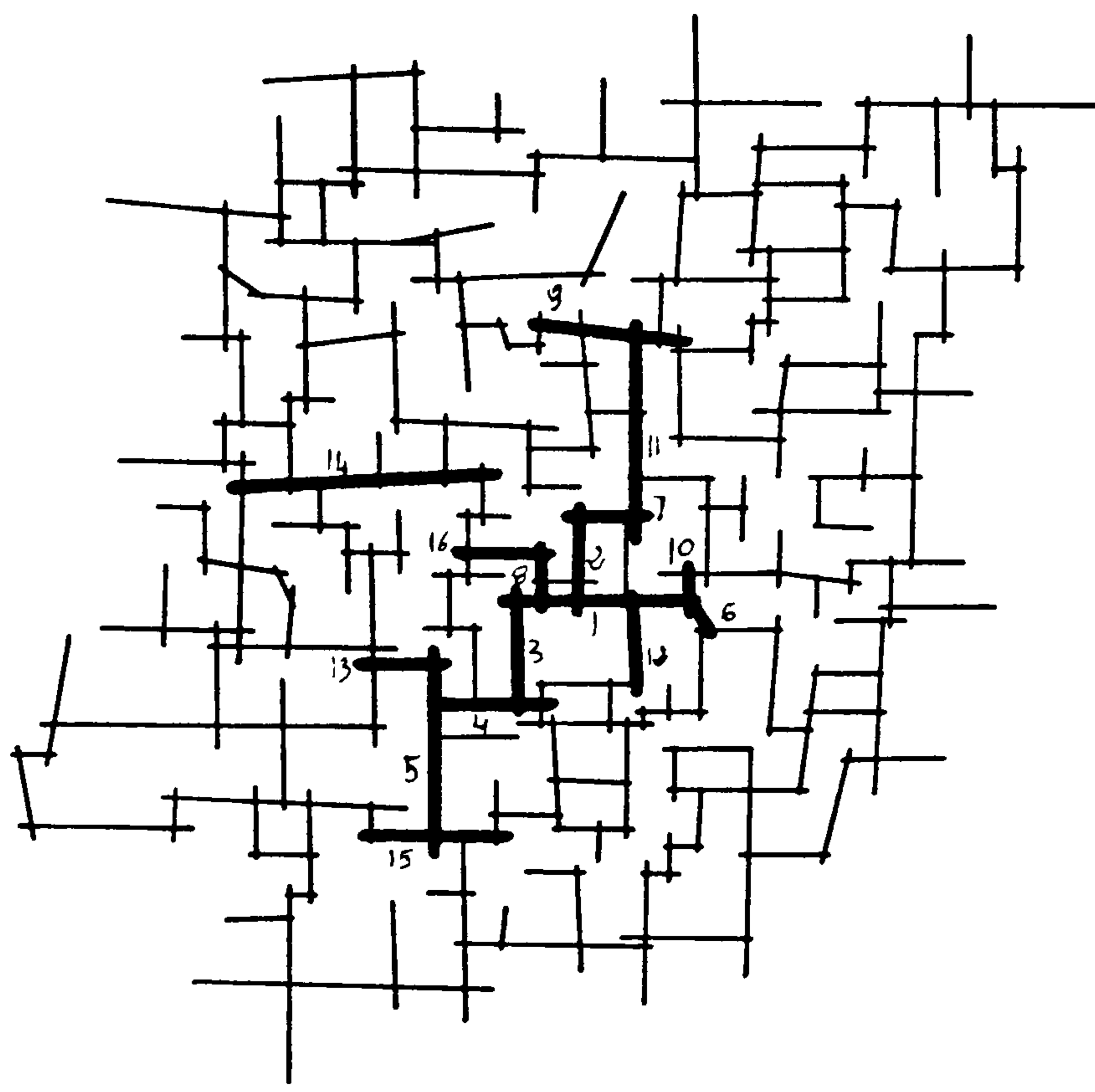

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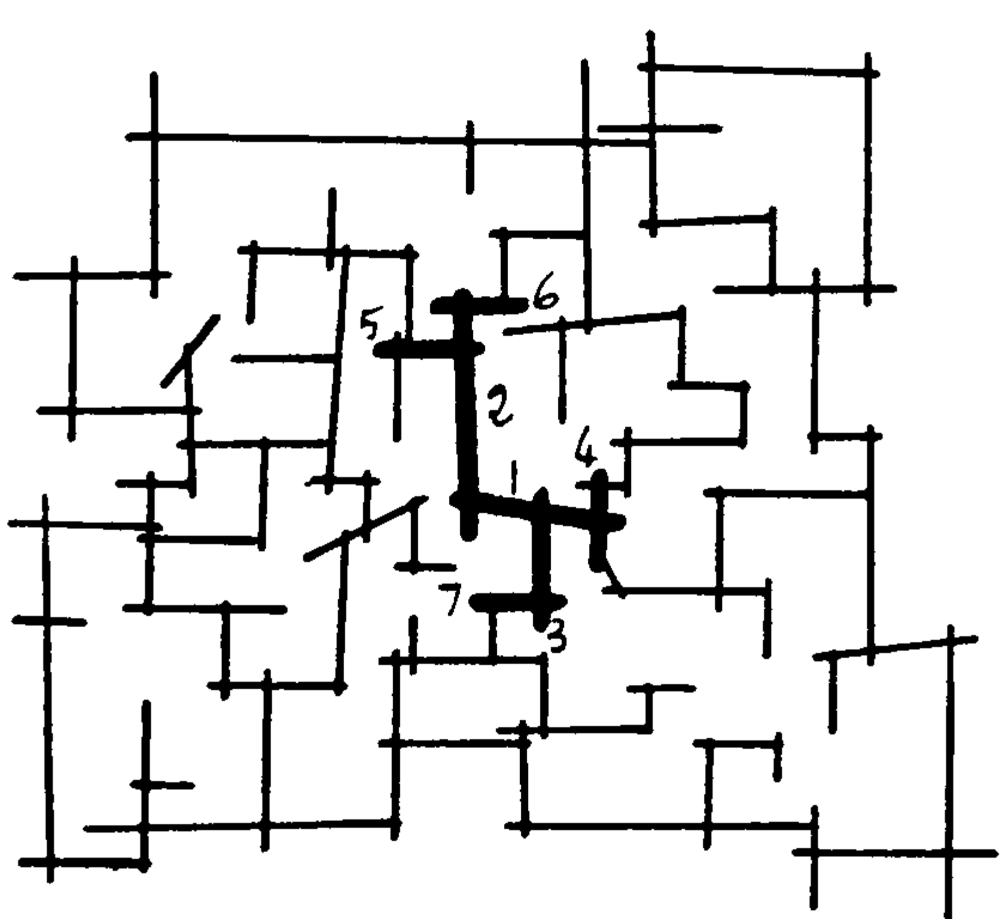

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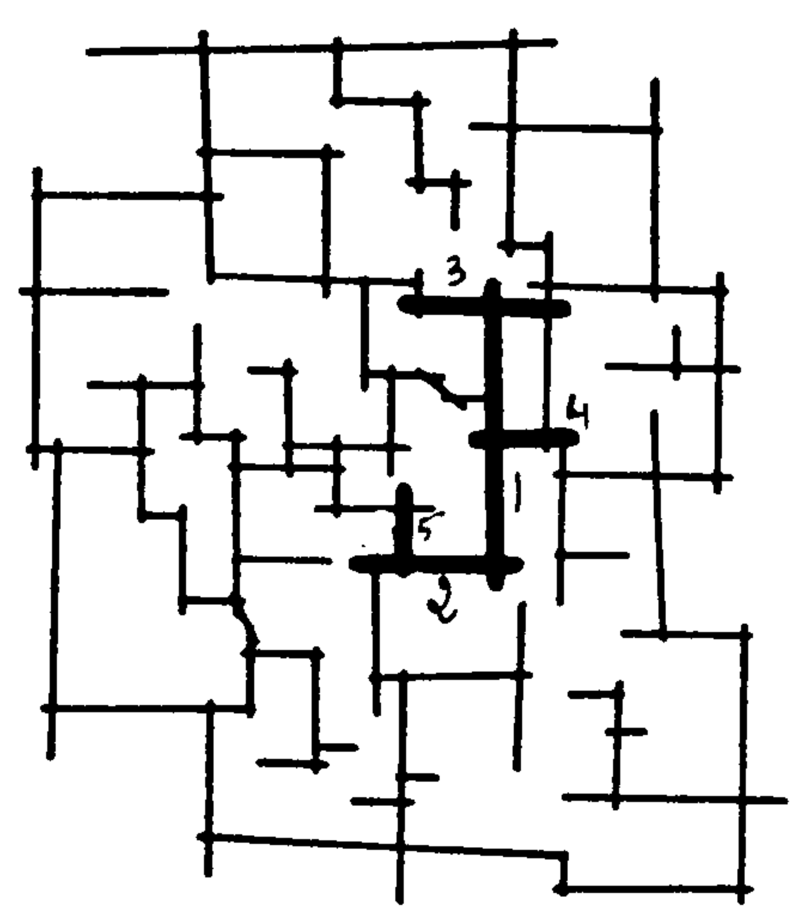
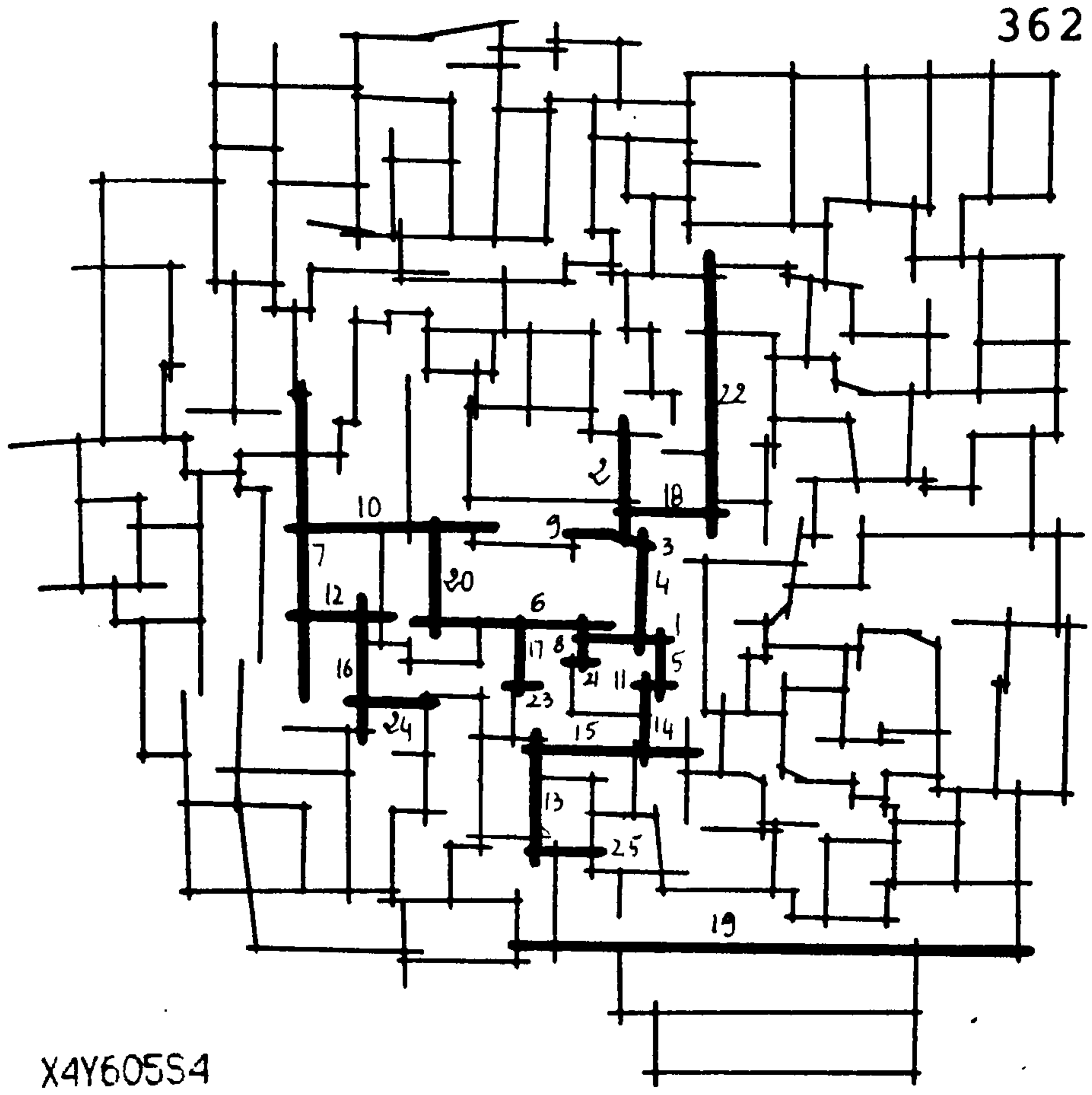


X4Y005S8

FIG. 5.17b : INTEGRATION CORES
PATTERN TWO



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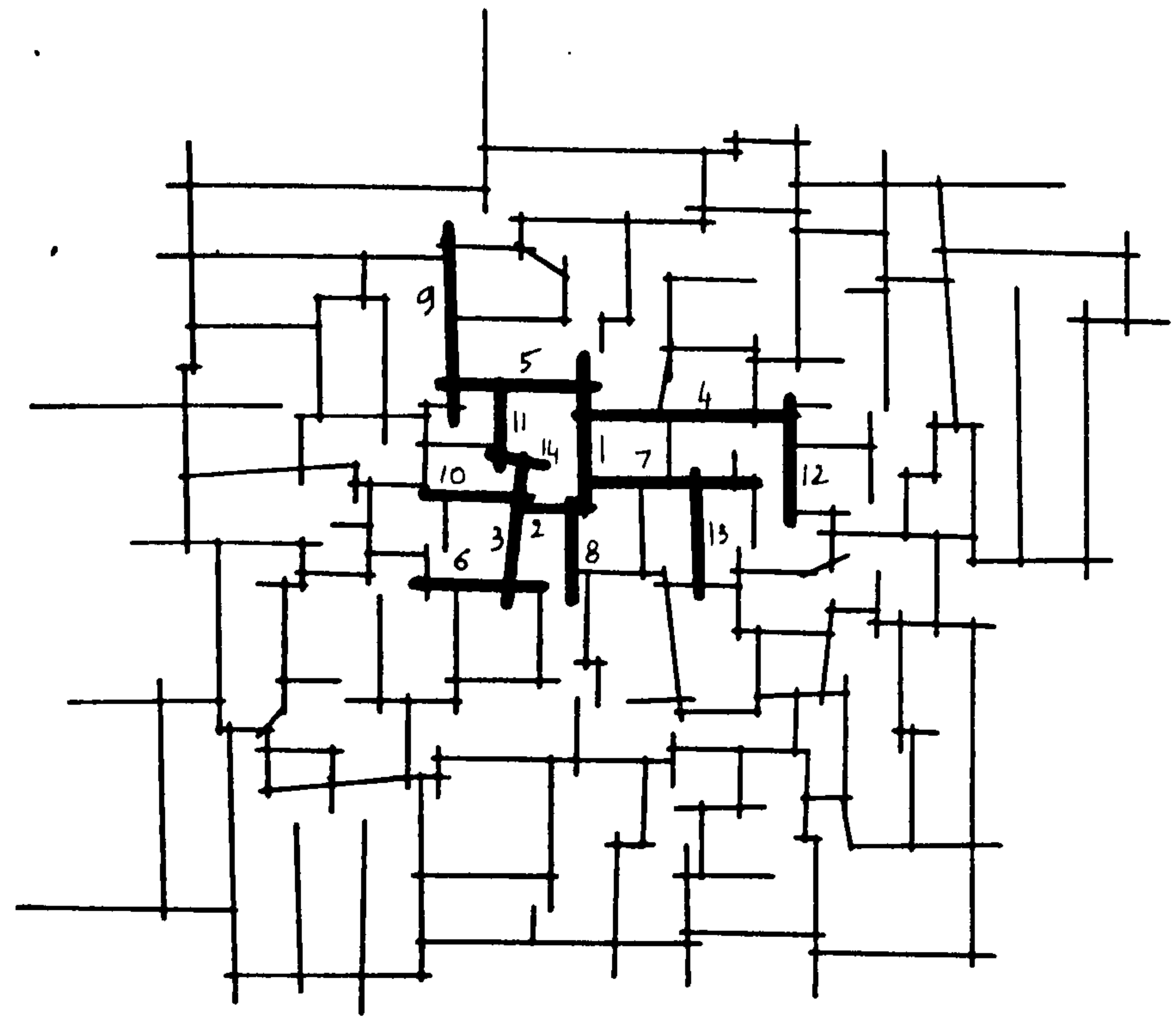

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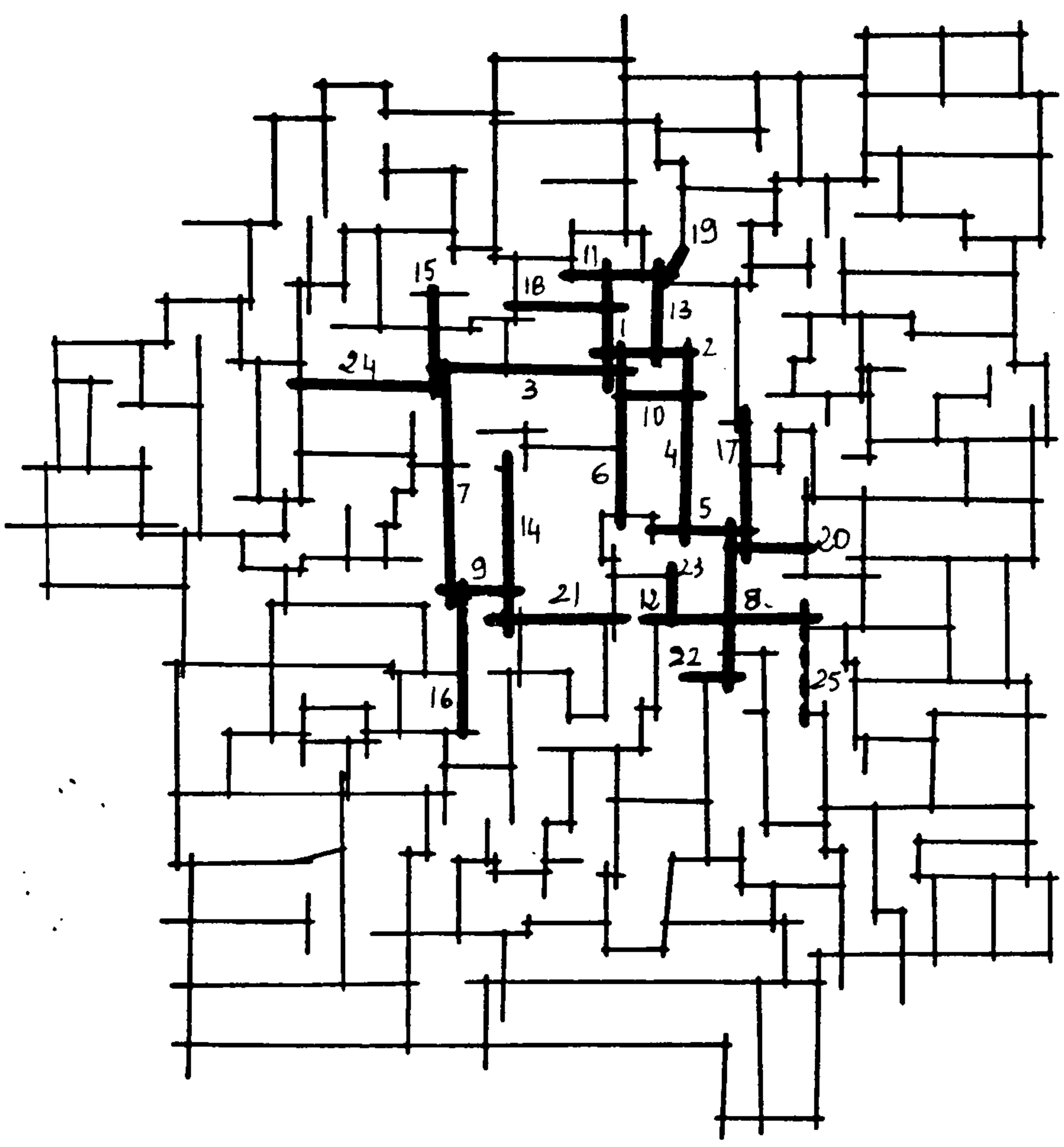

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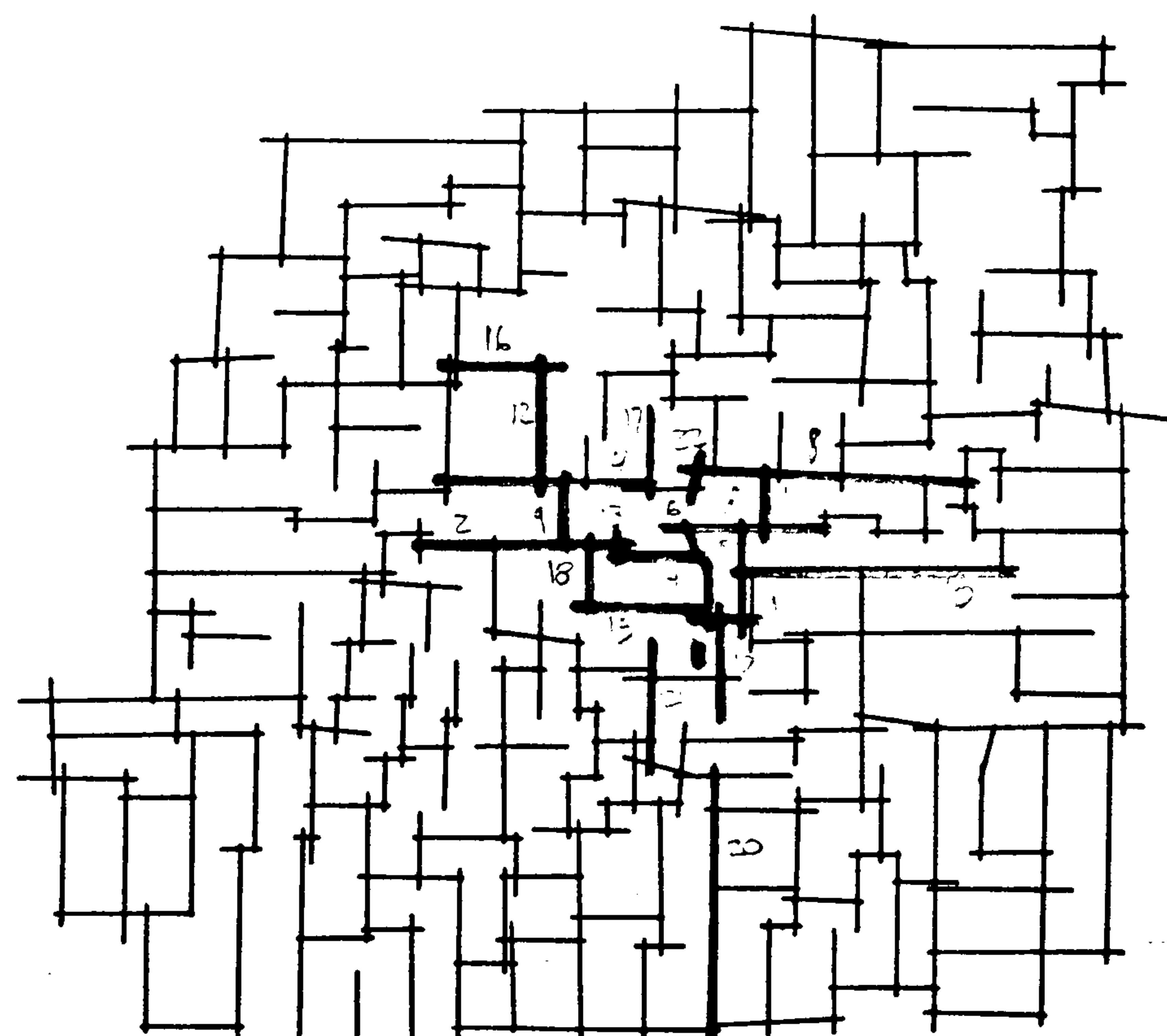

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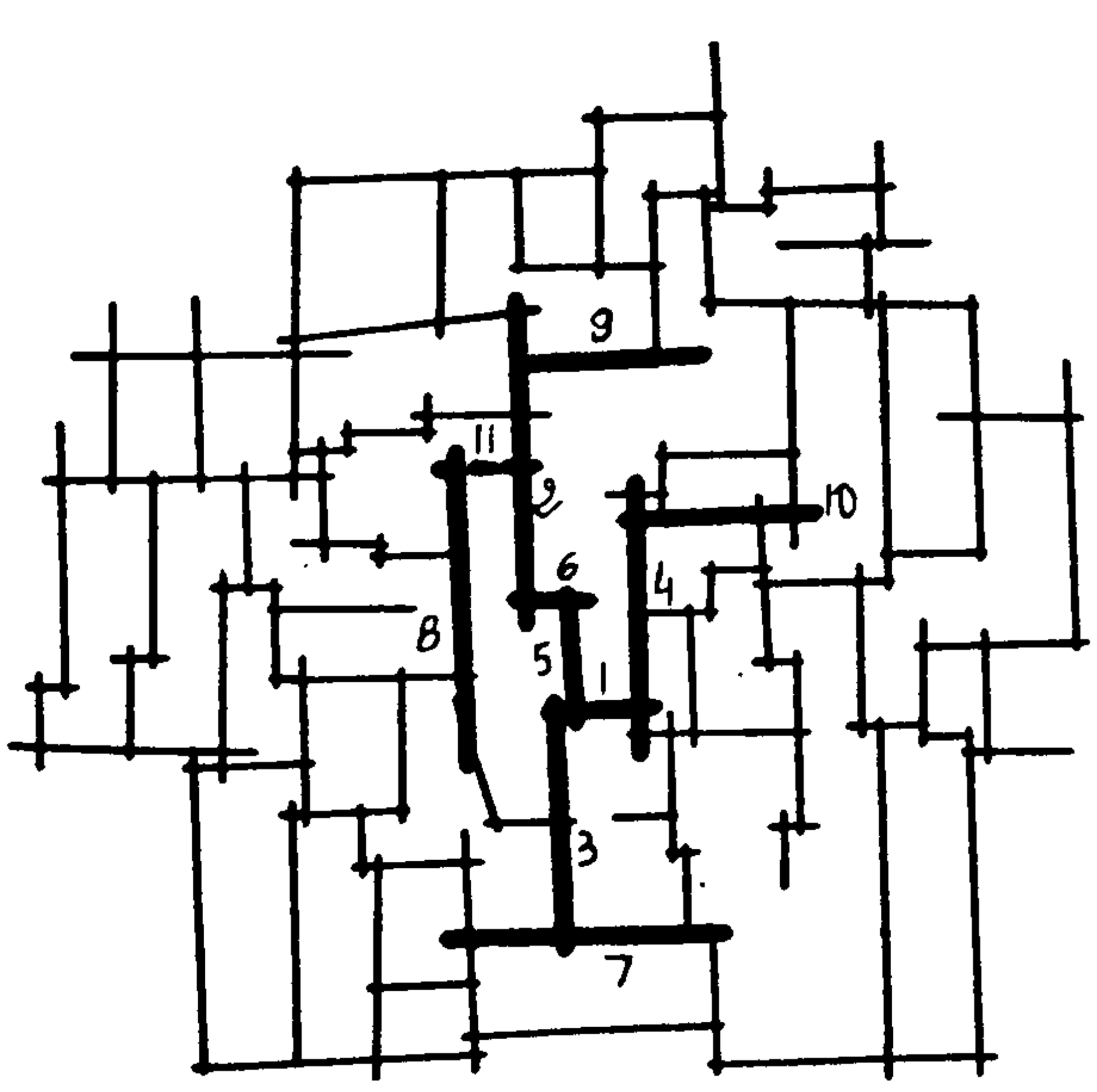
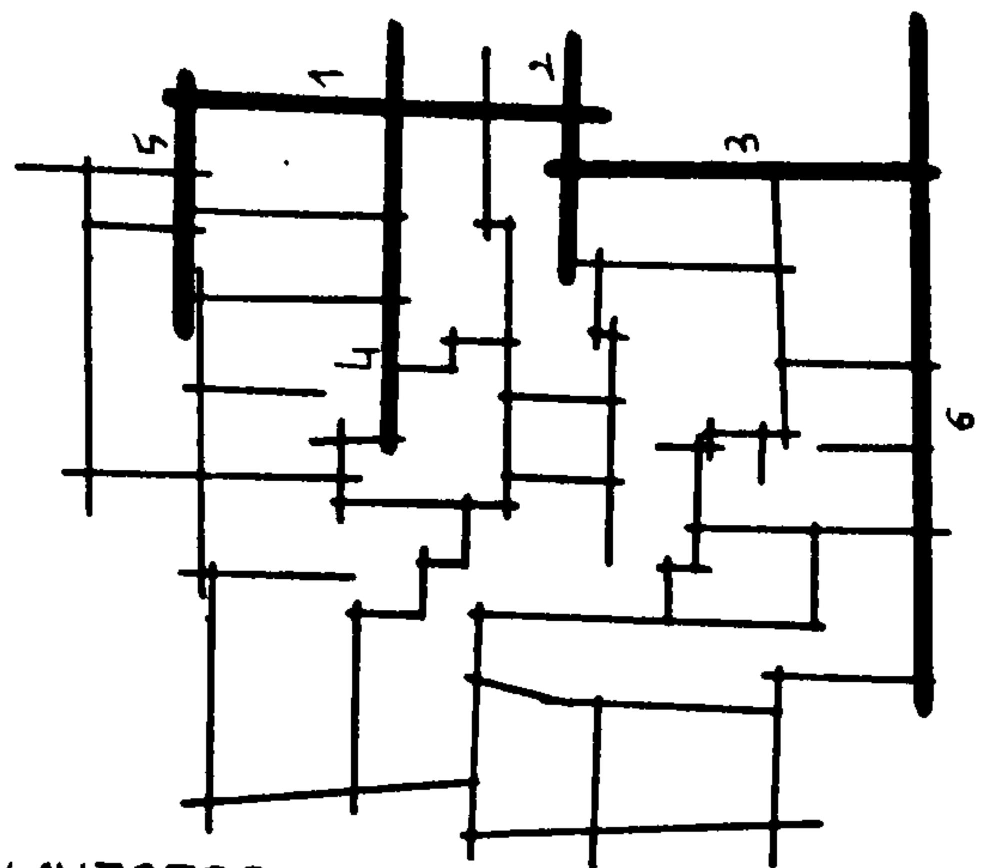


X4Y605S4

FIG. 5.17c: INTEGRATION CORES
PATTERN TWO



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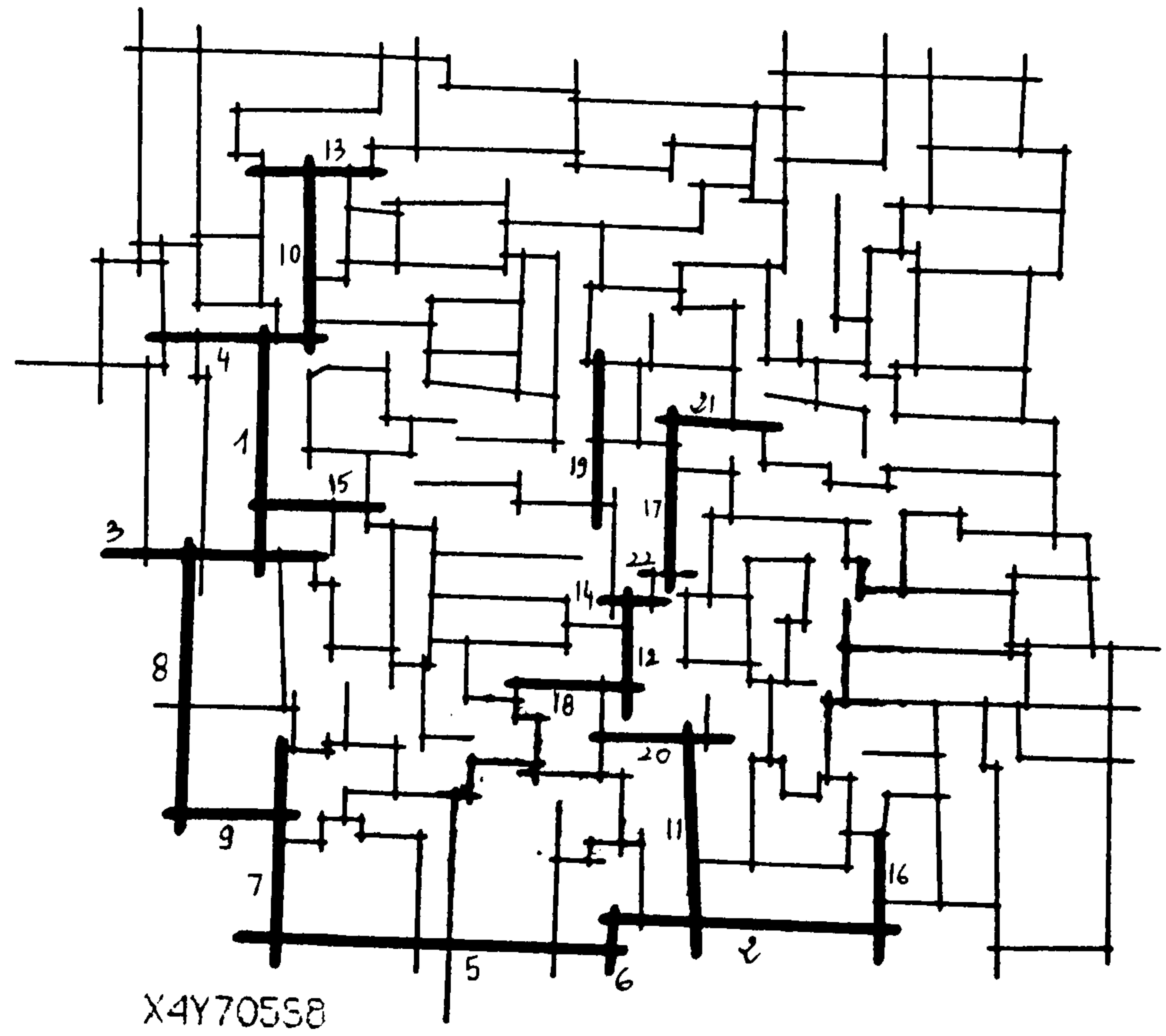

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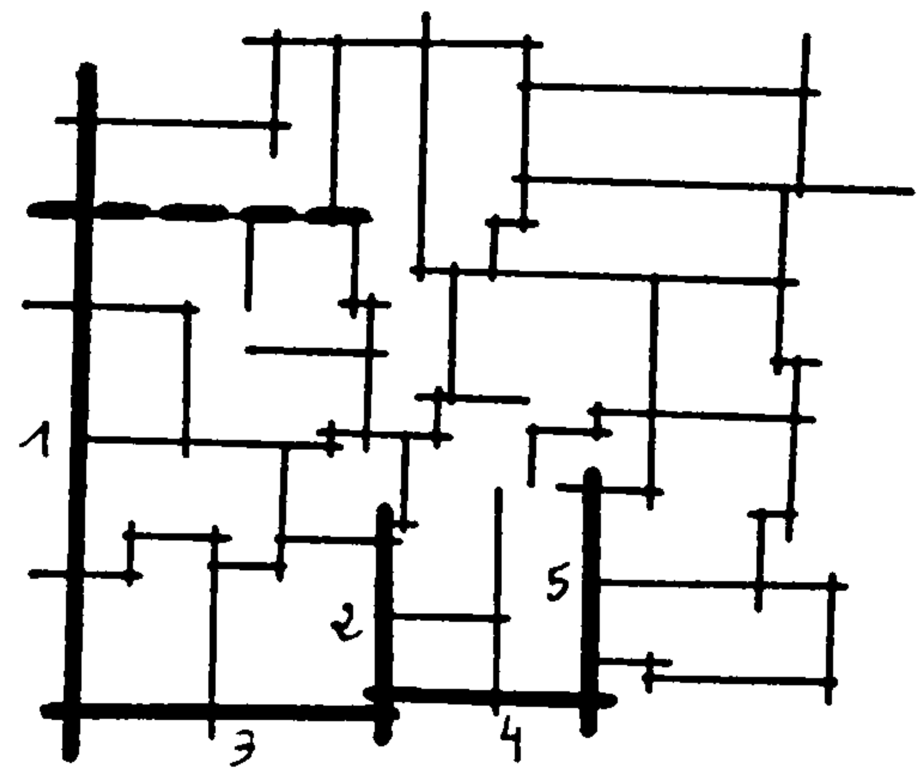

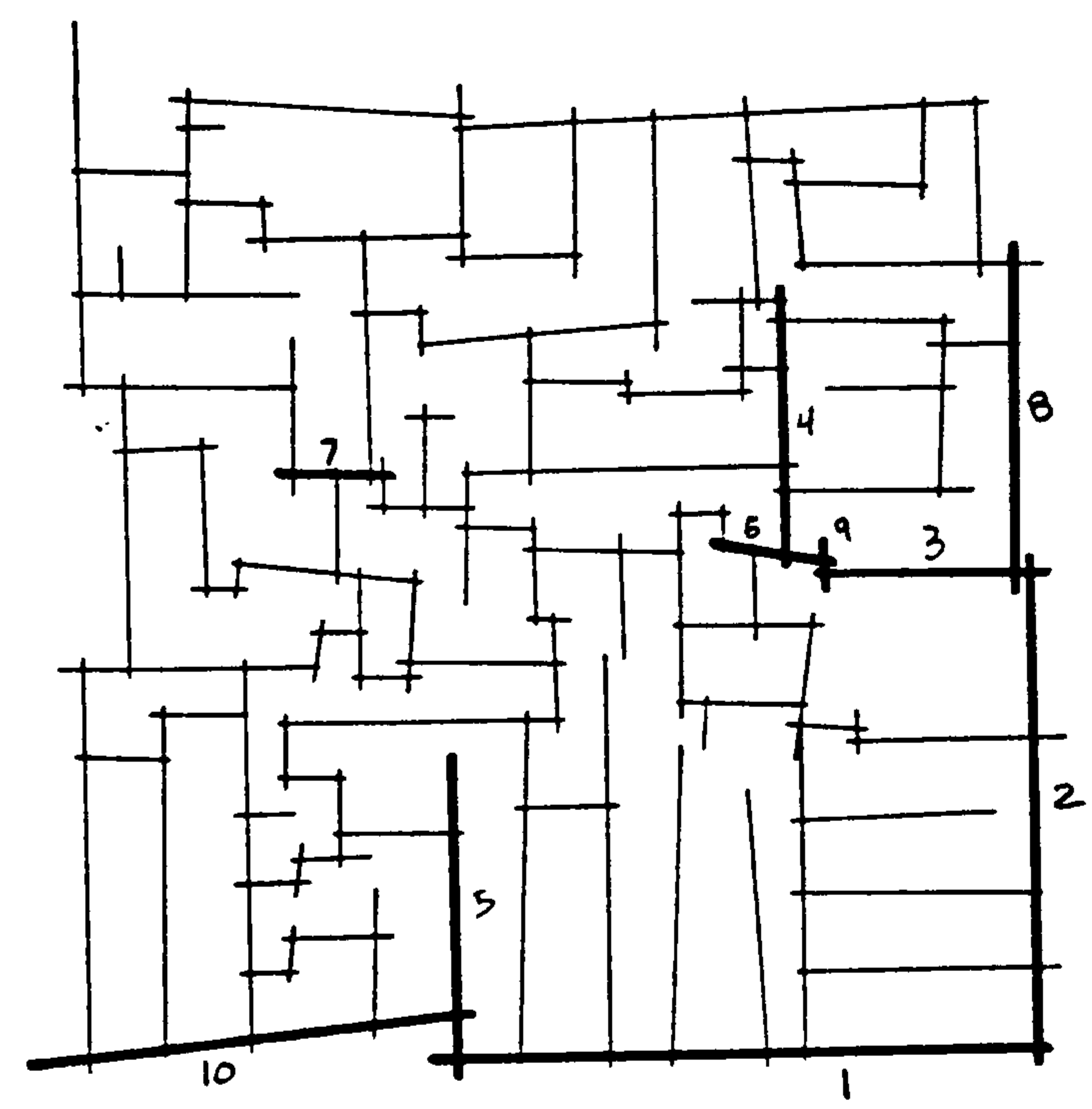

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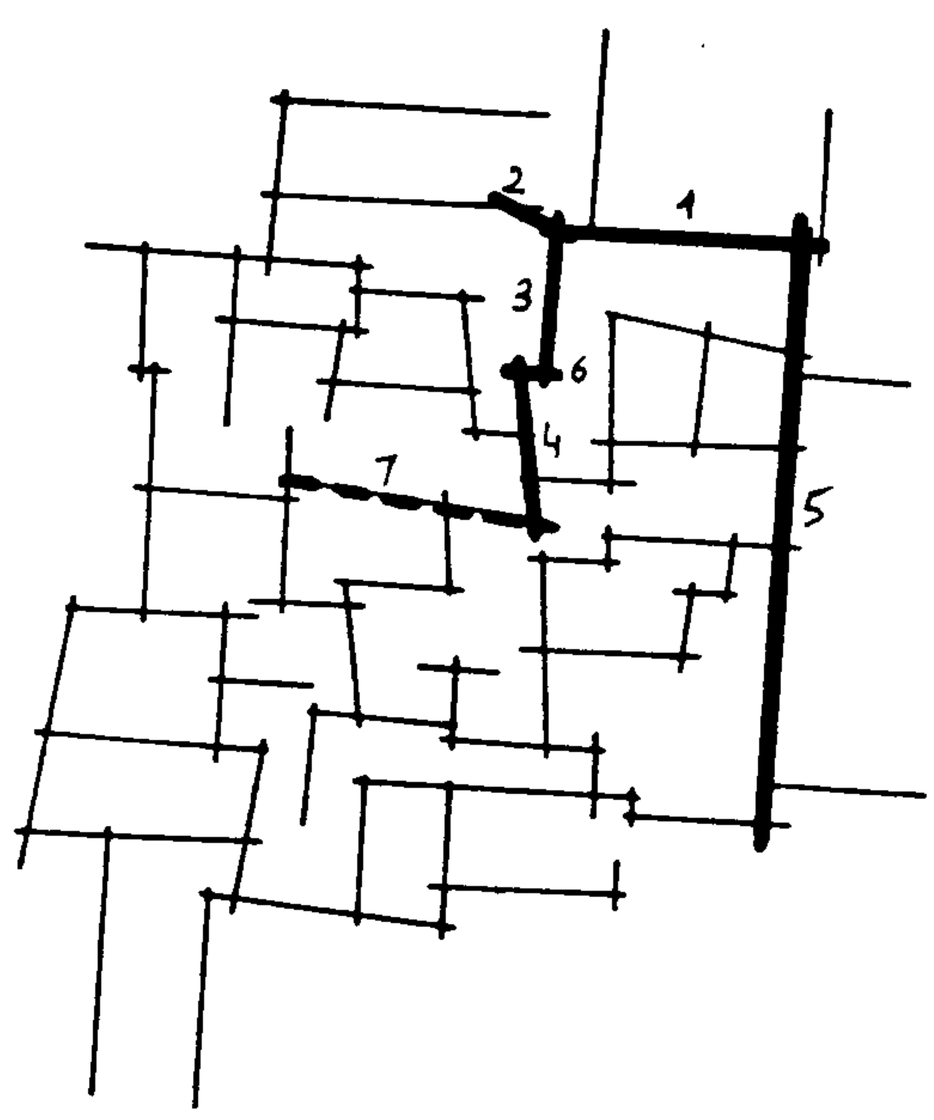

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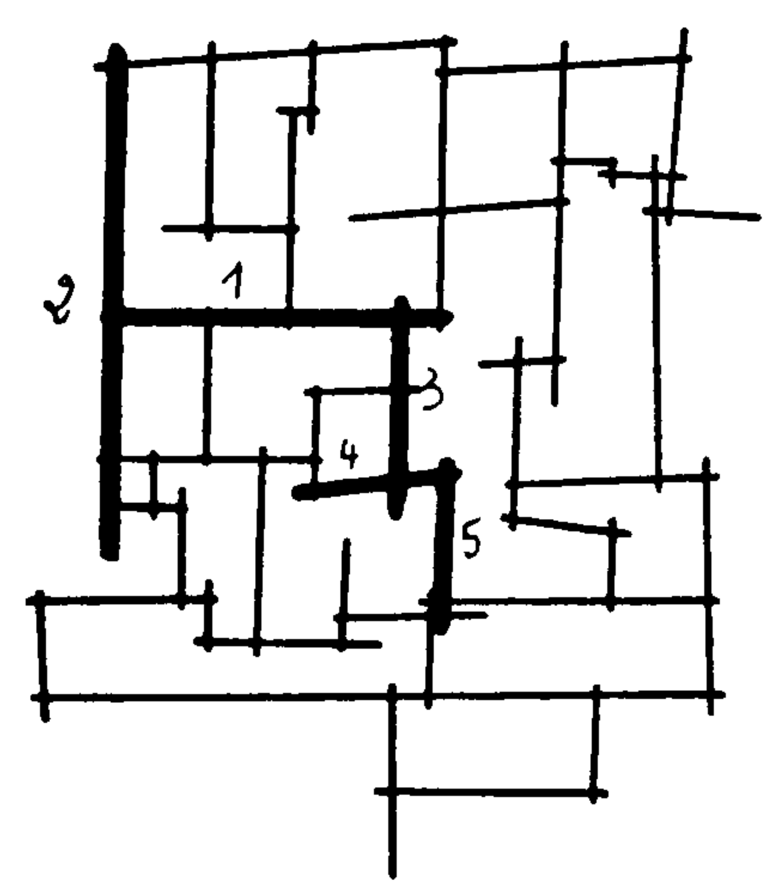

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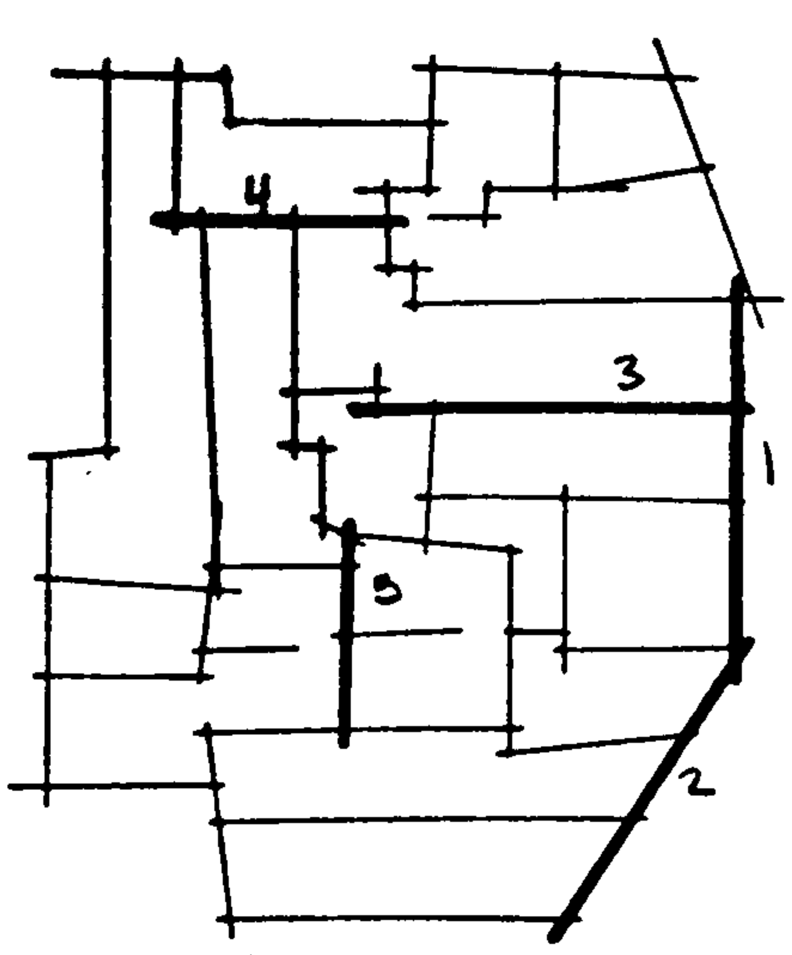
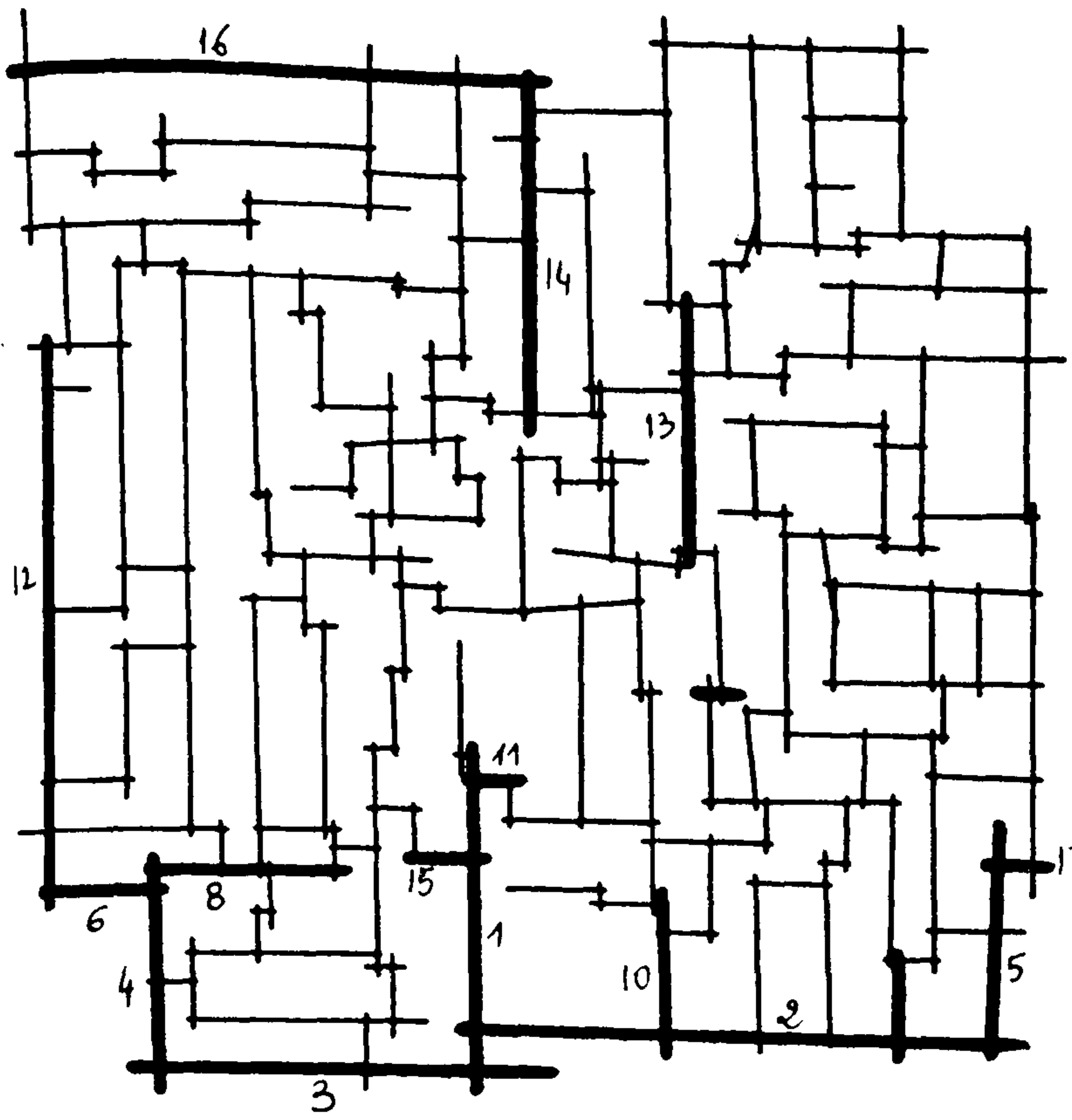


X4Y805S8

FIG. 5.18 : INTEGRATION CORES
PATTERN THREE



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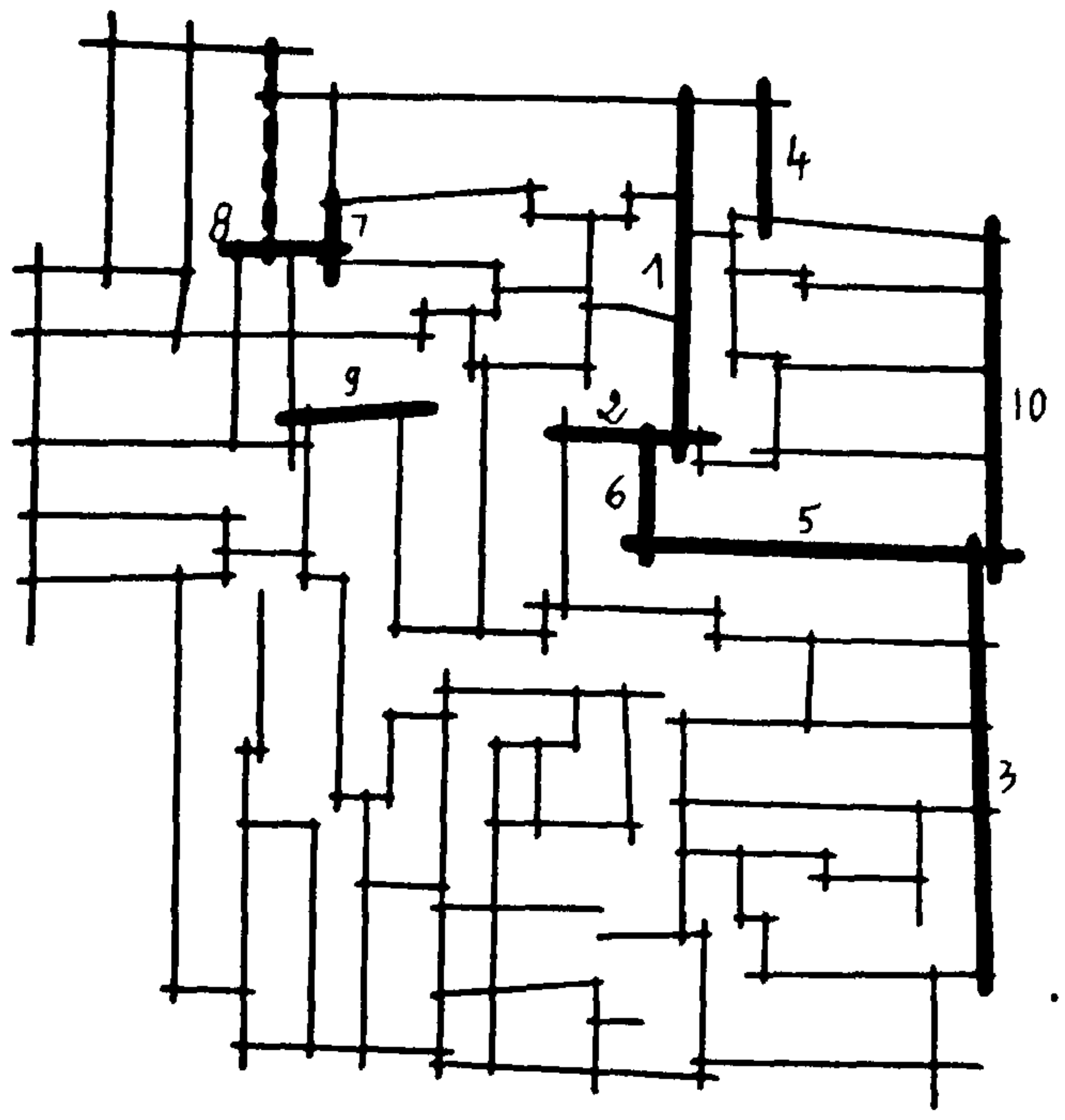

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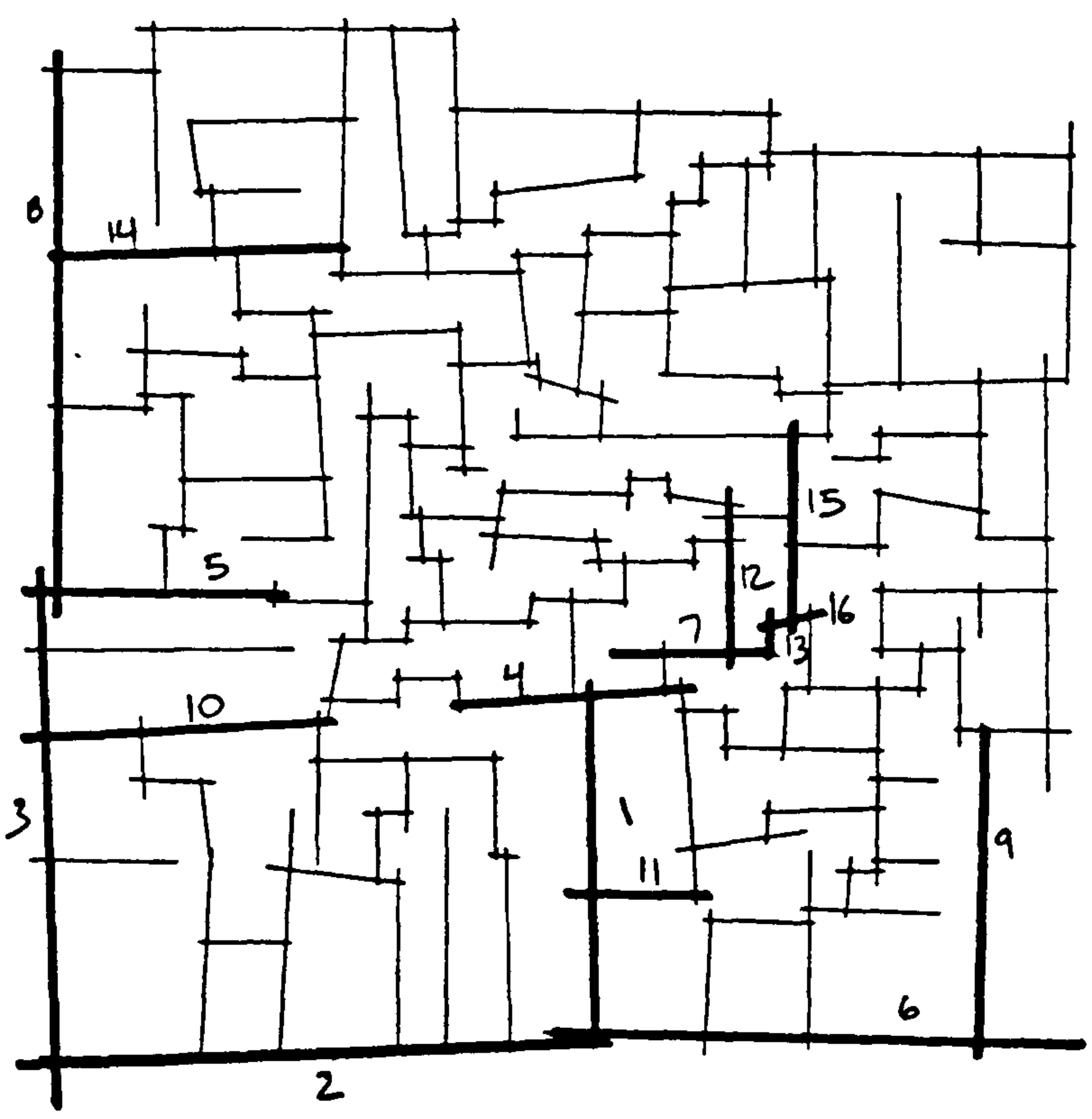

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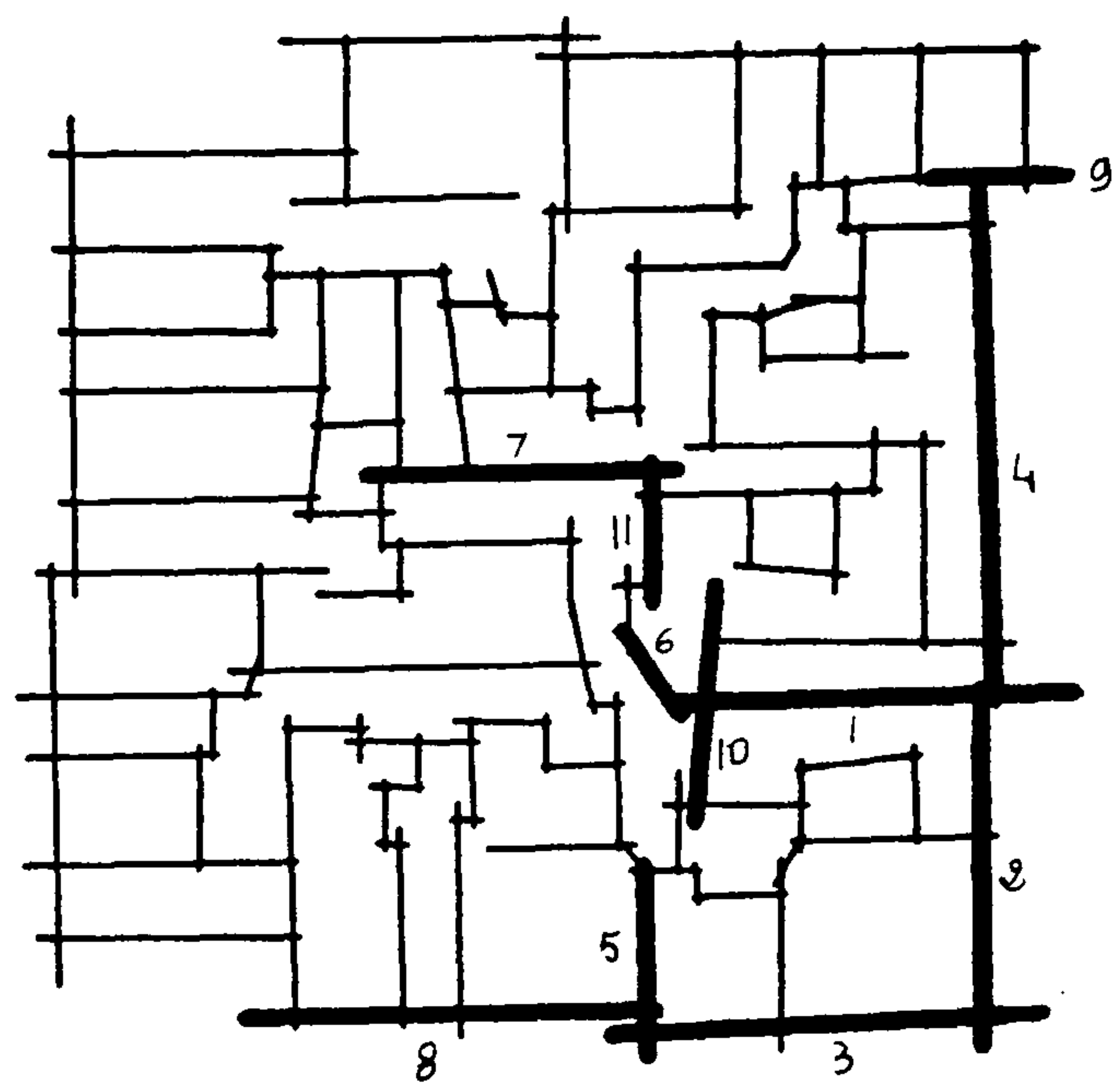

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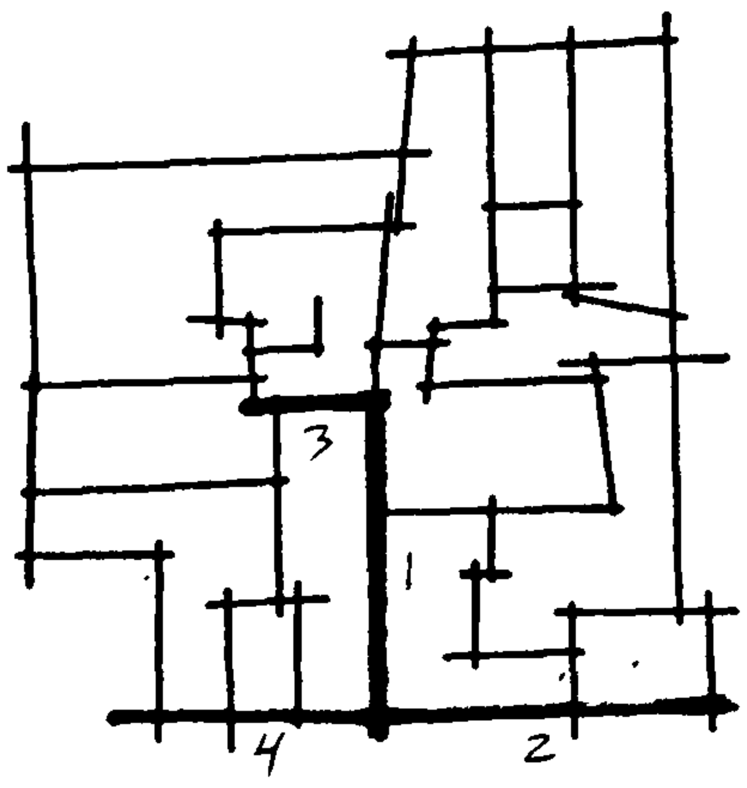

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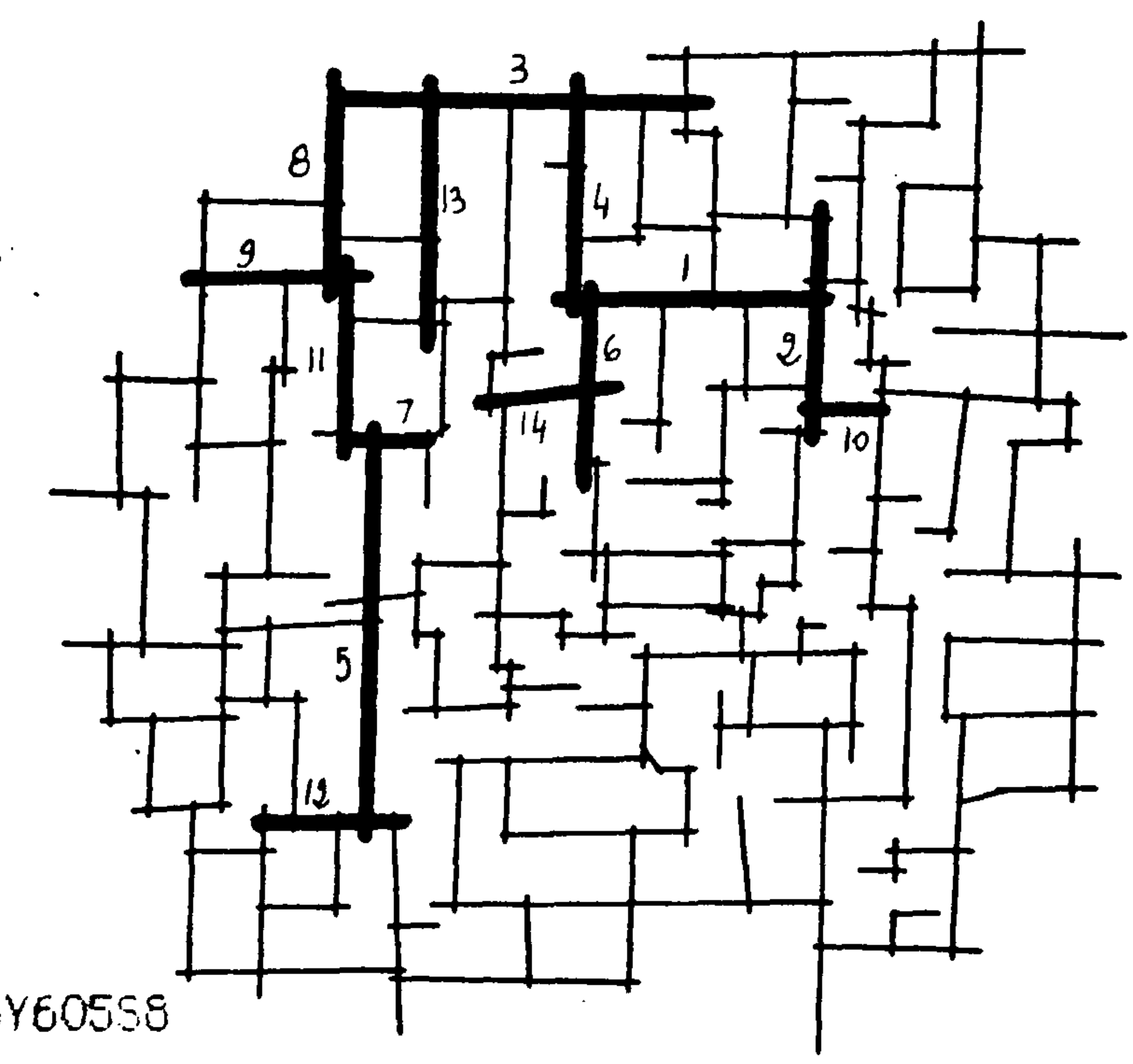
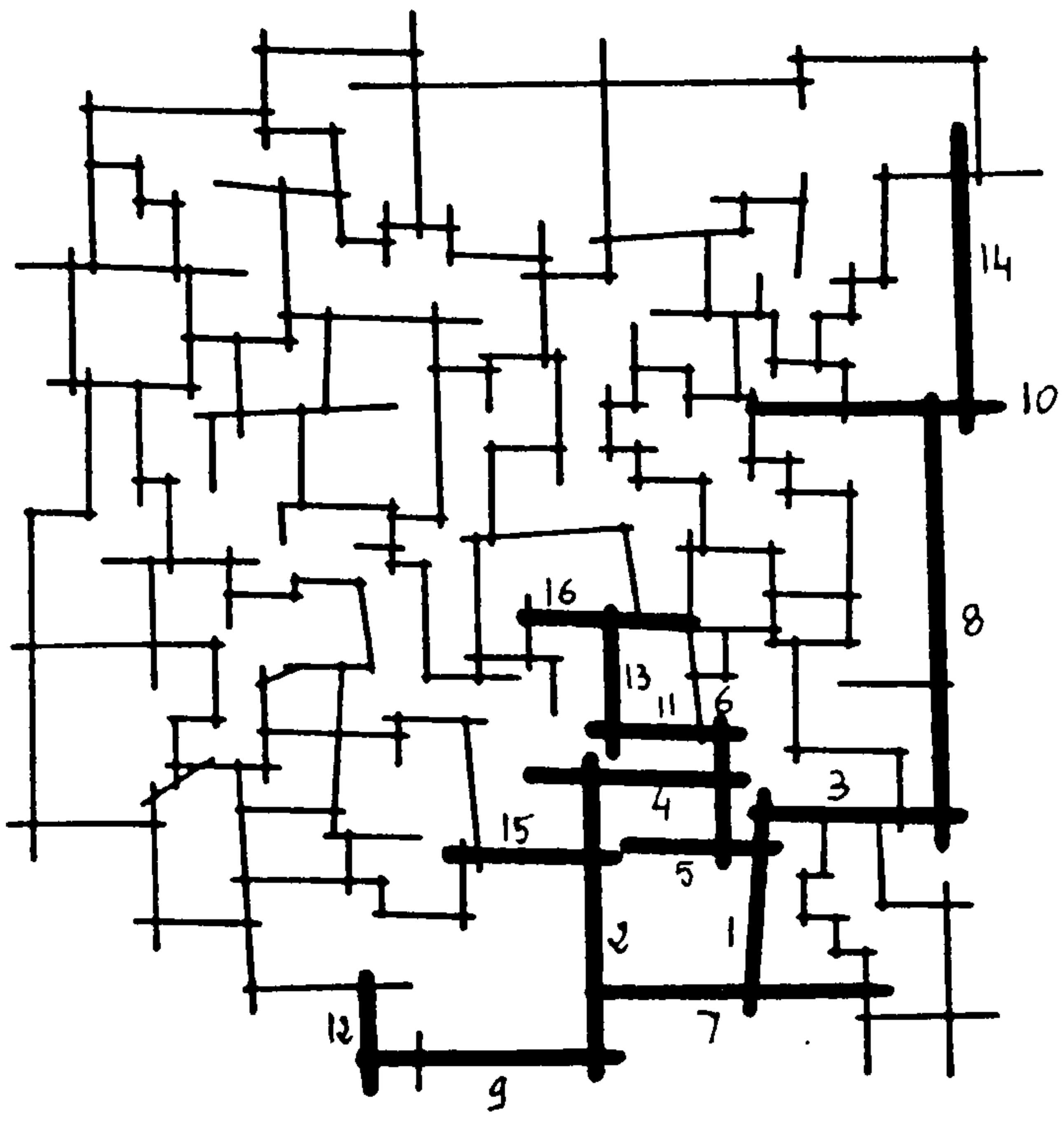
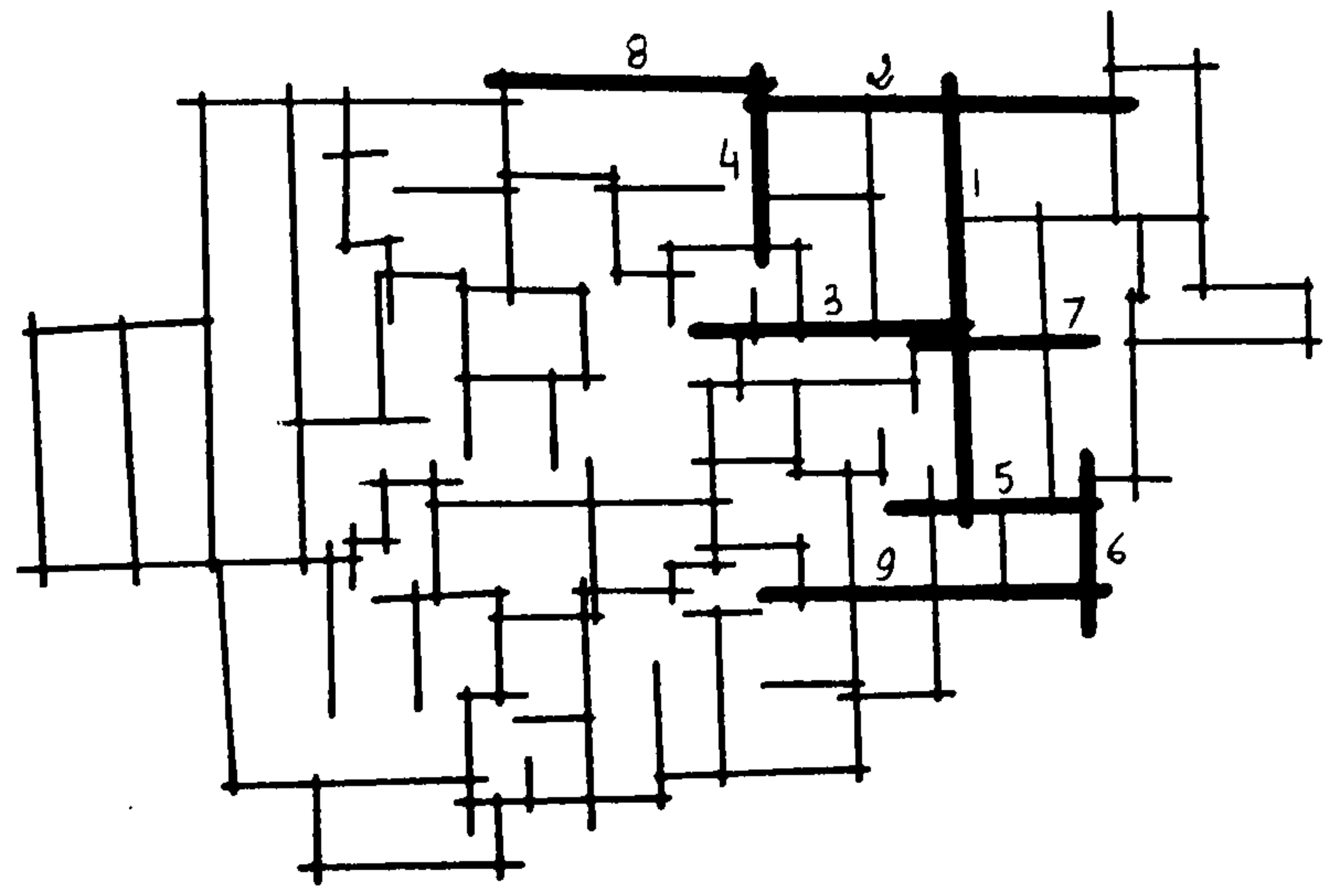


X6Y605S8

FIG. 5.18a : INTEGRATION CORES
PATTERN THREE

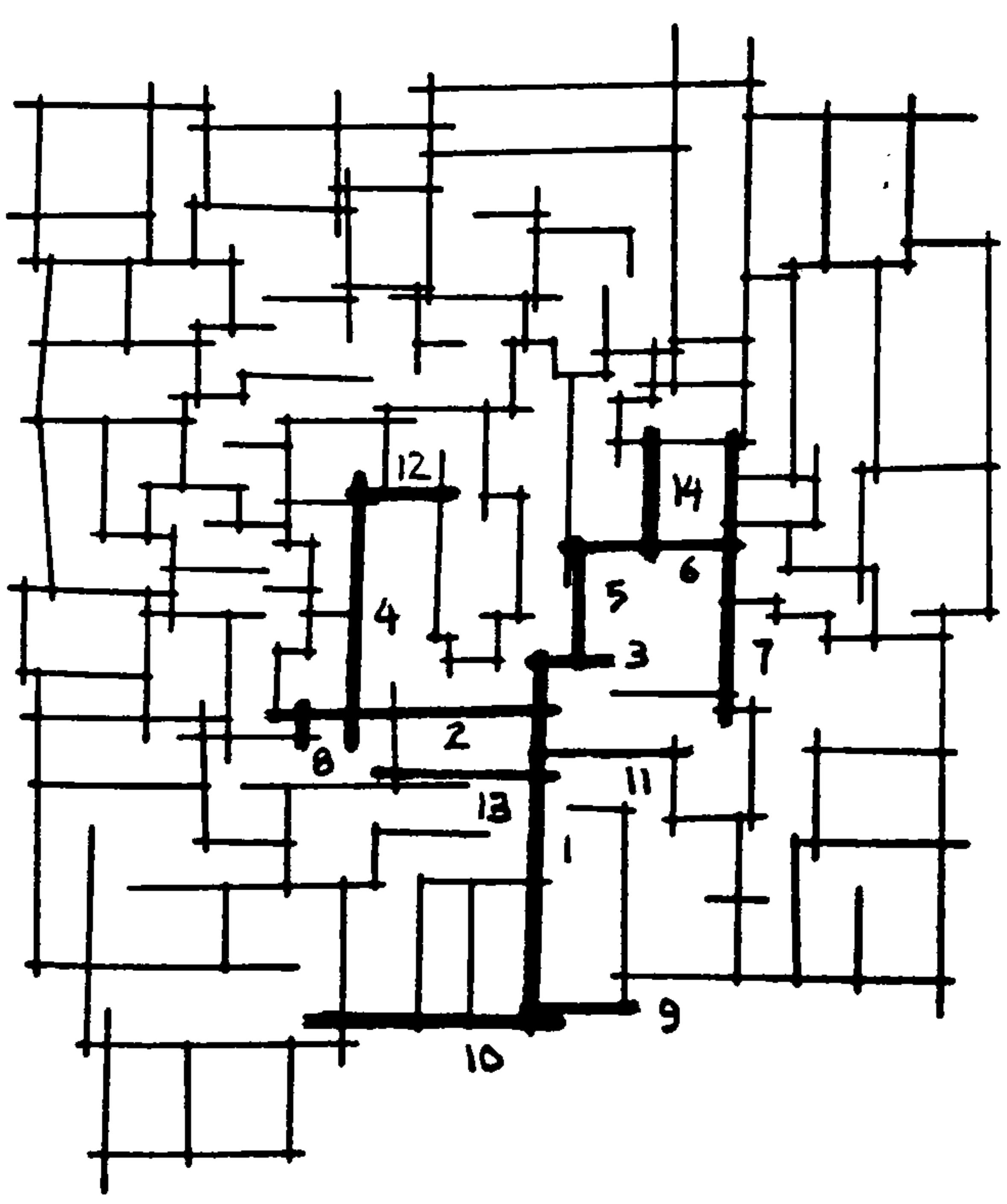


X4Y005S8



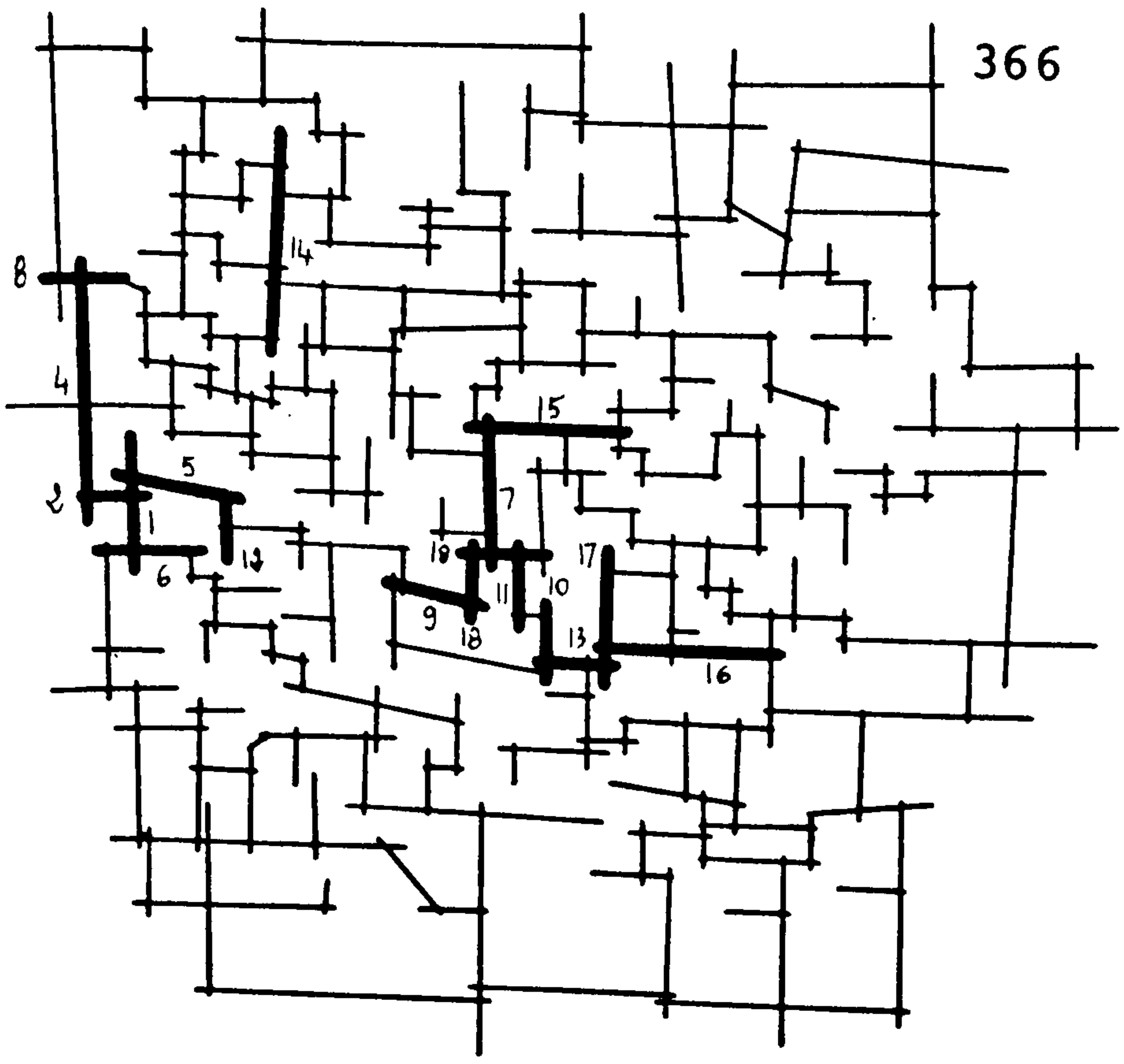
X4Y605S2

FIG. 5.18b : INTEGRATION CORES
PATTERN THREE



X4Y605S2

FIG. 5. 16c : INTEGRATION CORES
PATTERN ONE



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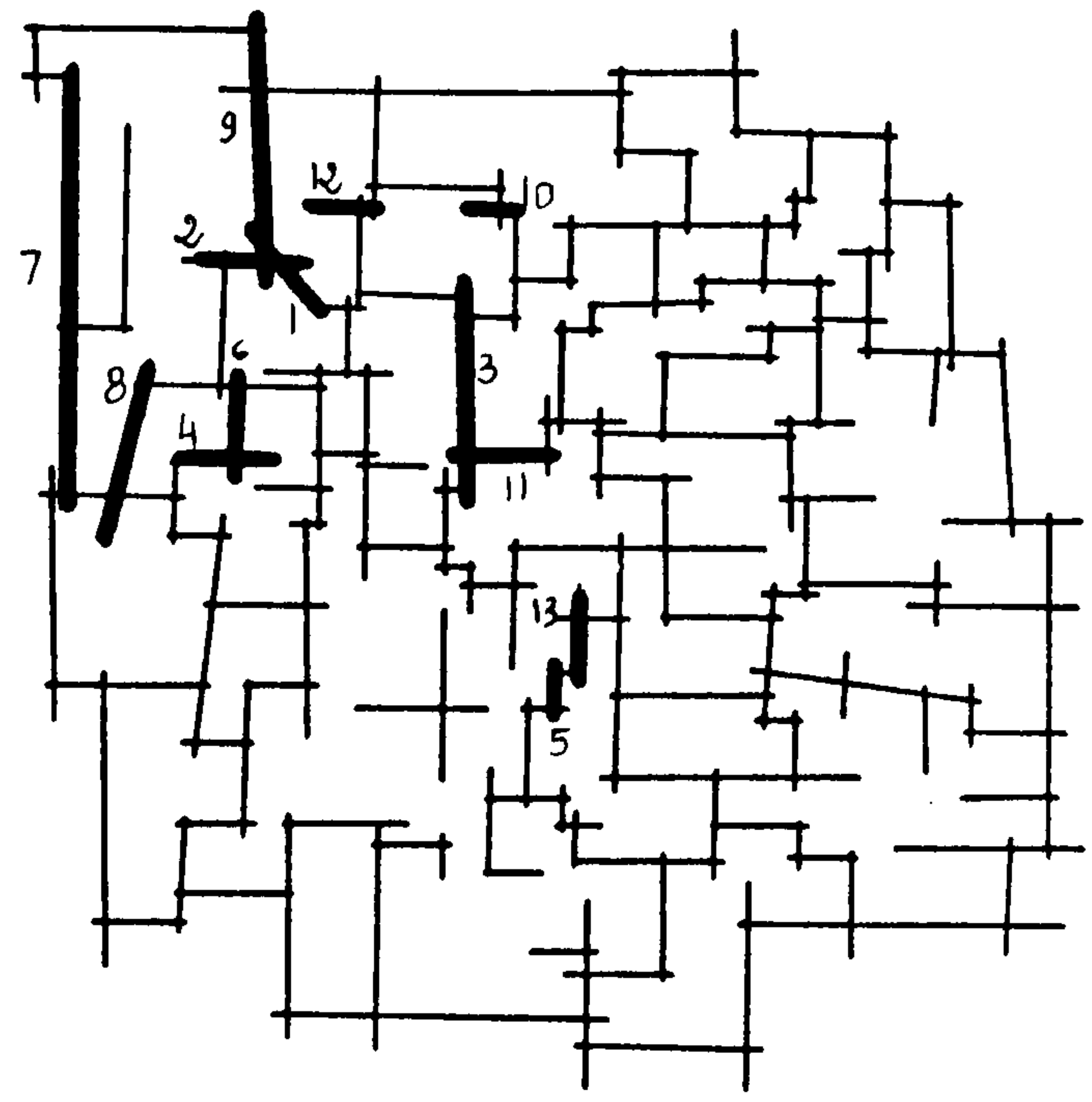

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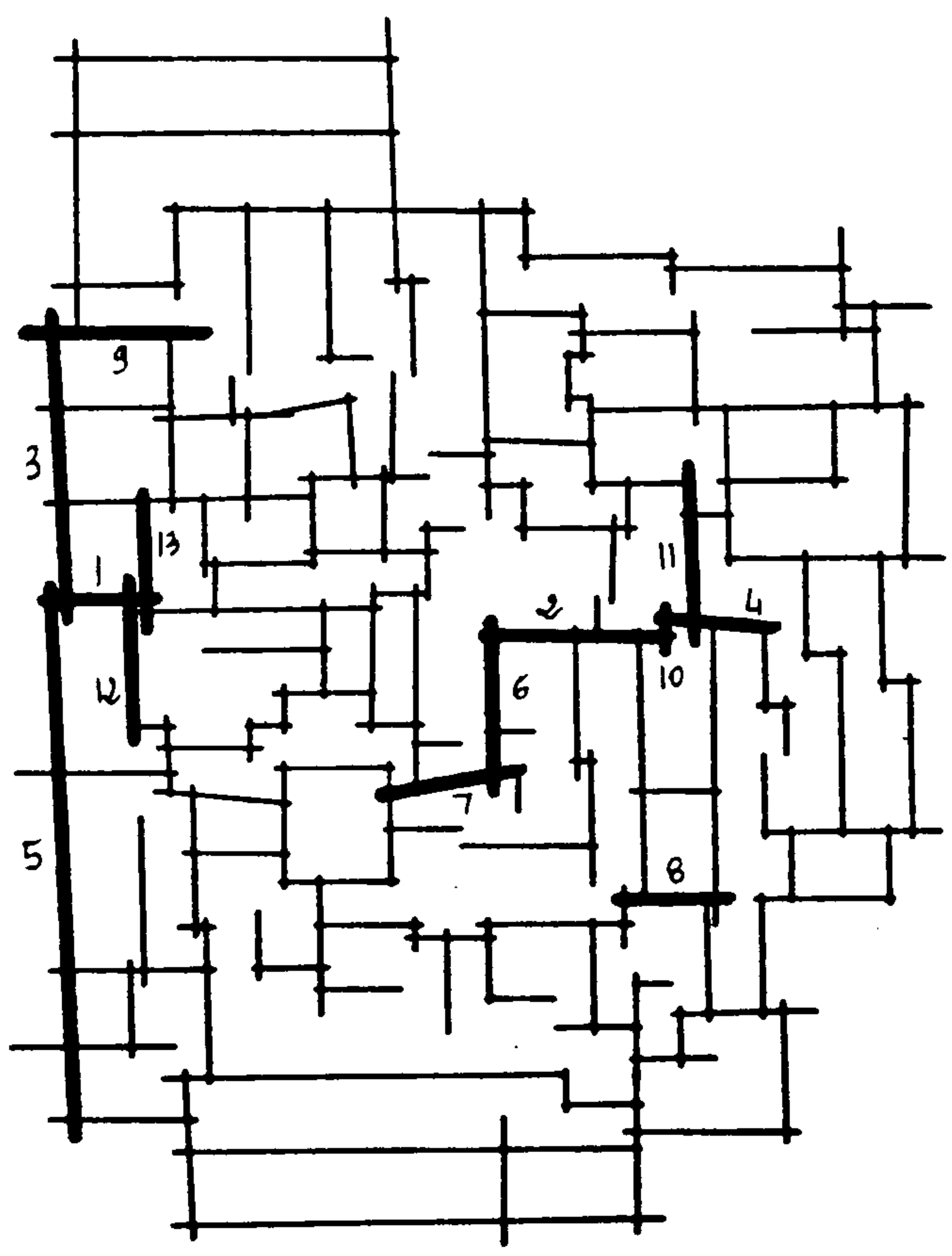
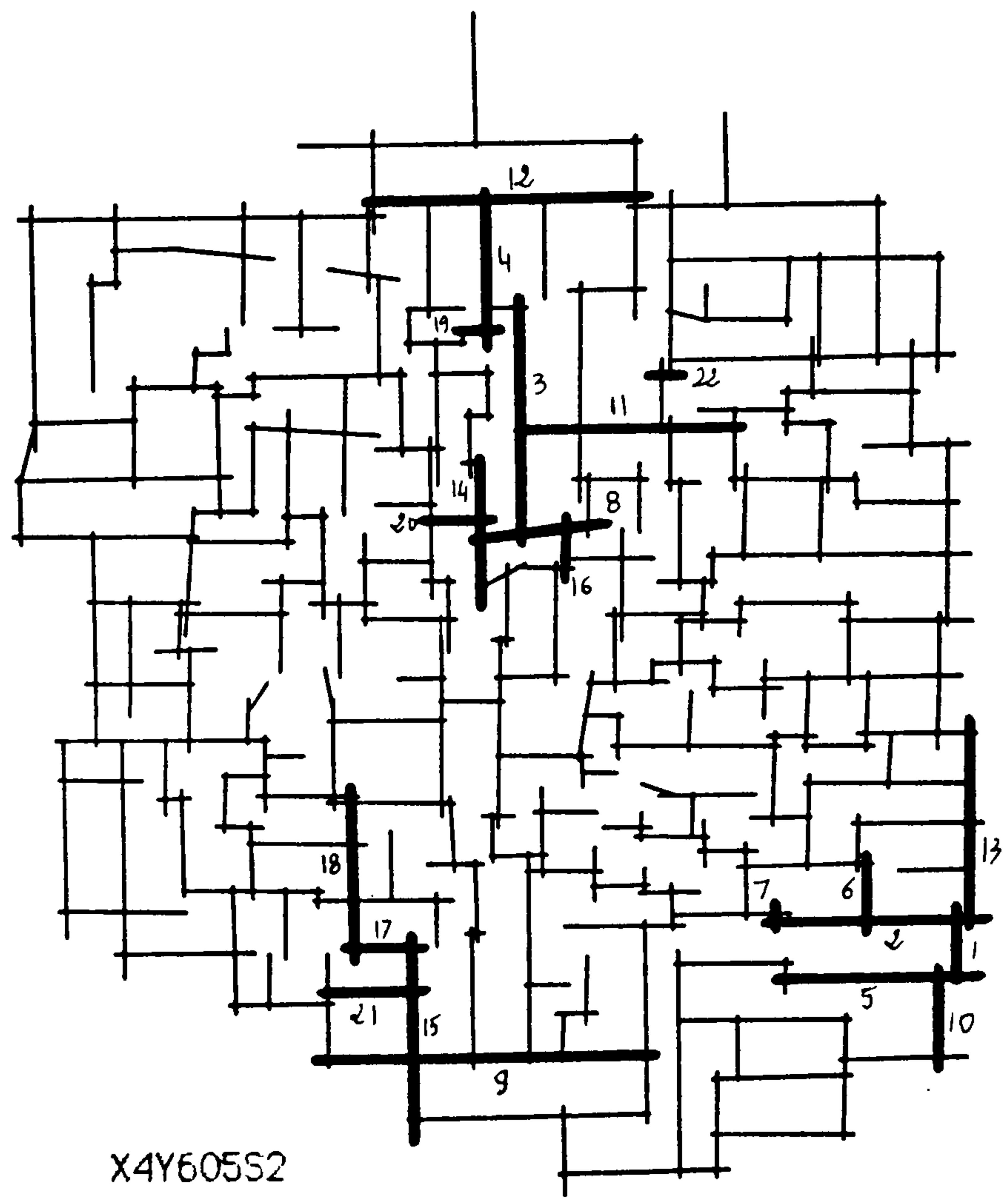
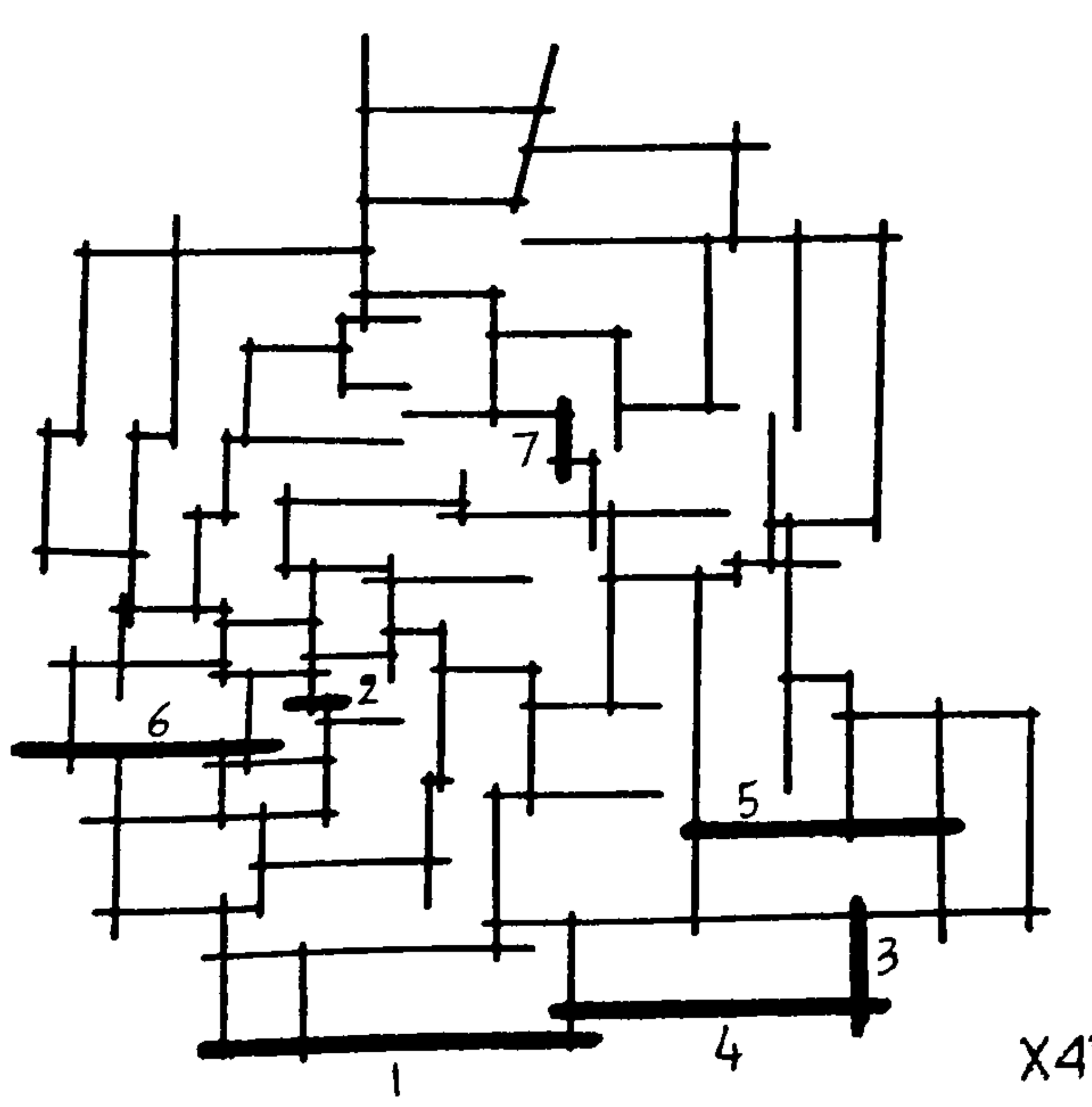


X4Y605S2



X4Y605S2



X4Y605S2

FIG. 5.19 : INTEGRATION CORES
PATTERN FOUR

tering (Px), the y joining (Py) and the y sliding (Ps). From the table, it can be stated that:

- There is a clear increase in Pattern Two when x clustering probability is increased. When there is no insistence on x clustering, that is x clustering is randomized (Px = 0), Pattern One and Three are predominant. On the other hand, when the situation is reversed with Py randomized (Py = 0 & Px = 0.4), a clear increase in Pattern Two takes place.

In the light of these results, it can be concluded that <u>the x clustering rule is more likely to produce more internal cores that are completely isolated from the outside</u>.

- A clear increase in the cases of Pattern Three, and a fall in the cases of Pattern Two when the y joining probabilities are increased. When Py is randomized, there is a net predominance of Pattern Two. When the open spaces or the y cells are forced to join to each other by the increase of the probability of y joining, a clear predominance in Pattern Three and One is noticed. This leads to the conclusion that <u>the links of the integration core to the outside is likely to be manufactured by the y joining rule</u>.

- A clear decrease in the number of Pattern Four when the y sliding is increased. When the sliding probability is very low (Ps = 0.2), 5 out of 8 cases have produced discontinuous cores. On the basis of this result, it is concluded that <u>the continuity in the structure of the cores is more likely to be created by the globalizing rule of y sliding</u>.

Variations in the patterns of the integration cores can also be observed within the different runs of the same set of values given to the parameters, and may perhaps be attributed to the random factor built into the model. As pointed out in the introduction of preceding sections of this chapter, the model developed here is non-deterministic, in the sense that the outcome morphologies cannot be fully predicted from the rules, but depend on some factors which are independent of the model. This is provided by the random numbers which are considered as a means for unpredictibility. With intermediated probability values of the parameters (i.e. Px = 0.4, Py = 0.6) and the random factor, their dual effects will be working sometimes together and sometimes against each other, and the results will be to a certain extent, unpredictable as far as the overall structure is concerned, though the spatial properties can be fluctuating about some norms.

The comparison of the diagrams in figures 5.16 to 5.19 with the integration cores of the real examples in figure 5.15 shows a resemblance in terms of location and structure between the real and the hypothetical cases. For example, cases of Pattern One are similar in that respect, to the integration structure of Ghardaia, while cases of Pattern Three bore resemblance to the integration structure of Beni Isguen, and cases of Pattern Two are similar to Beni Isguen at the first and the second stage of growth.

CONCLUSIONS TO CHAPTER FIVE:

In the light of these results, some fundamental conclusions can be drawn at a series of levels:

First, the generative model of settlement growth has provided convincing evidence that the numerical properties of the towns under consideration could have originated from a process of growth of a more localized character. The variation in the generative rules introduces variation in the global properties of the town fabric. For example, it has been demonstrated that an x-led process leads to a more segregating fabric. However, an important difference is observed between the real and the simulated systems in terms of the relationship between the integration and size. In the towns in question considered as a group, the integration does not correlate strongly with size, that is the towns under study do not become much more segregated as they grow larger, and suggests that there is a change of a particular kind in the growth process. The results of the analysis of the towns and the generative model point to two possible ways regarding the nature of this change: a change in the process from an x-led to a y-led mode of aggregation; or an introduction of some extra rules with more globalizing effect on the growing systems. In the case of Ghadames, the analysis has shown no increase in the maximum connectivity and a clear decay in the integration of the town as a whole, suggesting therefore a more x-led process. For Beni Isguen and as the system becomes larger, there is a considerable increase in the maximum connectivity, although not internally; a clear improvement in the integration and an increase in the linearity of the blocks. These characteristics point to the conclusion that the system of Beni Isguen, as it evolves, becomes more y-led and also increases particularly its connections to the periphery.

The system of Ghardaia on the other hand, increases the maximum connectivity and also maintains the level of integration constant throughout its growth. The lack of improvement in the level of integration suggests that in this case, the system may have followed a more x-led process, but may have also increased using a more globalizing rule, the connectivity of the market area. A suggestion about the kind of globalizing rule that may have been used is advanced. This is related, as suggested earlier, to the possible effect of the town walls that contain the evolving settlements on their global organisation. The decision concerning the construction and the position of the fortification walls is certainly taken at global level by the town council (Donnadieu and Didillon, 1977, p. 55). When the walls are built, a ring of open space is usually left between the walls and the rest of the urban tissu; that space becomes part of the street system, in the sense that many buildings begin to be built along side it and have their entrances giving onto it. The walls are demolished during the course of growth to be built further away; but the ring of open space would preserve its structure mainly because of the buildings giving onto it. The examination of the location of the integration cores (see fig. 5.15 and 5.15a) for Ghardaia and Beni Isguen at the different stages of expansion, in relation to the limits of the towns during these phases, lends support to the above suggestion.

Second, the regionalization of the town structure and the lack of covering core is not the result of the location of the major town facilities (i.e., the main mosque and the market square), but can be attributable to the nature of the fabric of the towns, and the way they grow.

Third, the "covering-type" of integration core is not produced at all by the variation in the local rules embedded in the model. It can therefore be concluded with more confidence, that such structure results from more globalizing rules imposed on the growing systems.

Finally, another interesting result is that the model has shown how the global structure of the settlements can be a by-product of the form generative process and not a mere reflection of one prime factor such as religion (i.e. the argument relating to the privacy model).

This suggests that the social hypotheses of the settlement forms could be more usefully formulated in terms of the underlying generative rules. This particular point will make the main concern of the next section.

Moreover, the consideration of the above points suggests that the local rules embedded in the model have produced a kind of "spatial global effect" which is partly random. By building very densely, that is by insisting on x clustering, the overall effect of the application of this purely local rule will be more likely characterized by the increase of the size of the blocks of buildings; which is a fundamental <u>formal requirement for the potential development of the terrace system</u>. The more there is insistence on x clustering, the more likely the size of the block becomes larger, and the more the settlement has the physical potential to develop the terrace system. On the other hand, the regionalization and the non-covering nature of the integration cores is another spatial global outcome of the local rules. It is clear that the access structure in the settlements of interest was essentially unplanned; it is not the result of a planned "master plan", but was the cumulative result of numerous decisions and actions, individual or collective, over the centuries. The opportunities for access to any building were only constrained by the layout and access points of the already existing buildings. Such actions were not subject to global control. Therefore, the non-covering pattern of the integration structure can only be a global result of the combined effect of the local rules. So, the more the integration core is non-covering, the more the regionalization of the town is accentuated and the more the accessing of strangers is controlled and limited to a specific zone of the town. Therefore, the notion of spatial control can be related to the very nature of the form generative process of towns.

A conclusion that can be drawn is that the most essential imperative principle that has shaped the urban fabric is the localized form of growth process. It has been the prevalent force in the shaping of the built form.

The close correspondence between the spatial properties of the real and the hypothetical morphologies , and the "life-like" appearance of the latter both corroborate the process description advanced here. The basic principles of growth have held good for most experiments. They represent the morphology in its simplest form. The generative procedure has helped to define much more precisely what spatial forms were possible. That is to say, it helped to describe the limits of what could actually have occurred within the social context of the settlements of interest.

The above findings suggest then that many of the morphological characteristics observed in the towns under study, could be accounted for by the spatial logic of the system. The visually complex, but nevertheless very ordered, spatial patterns of this settlement type arose from the consistent application of rather few local rules within the context of a rather narrow and consistent set of constraints. Thus, while far from deterministic, the pattern of building and open space may be seen as probabilistically dependent on the system of relations between the basic principles of growth.

THE SOCIAL IMPLICATIONS OF THE GENERATIVE RULES:

In the following section, an attempt will be made to look at the social implications of the generative rules. The present section aims, using historical evidence, at the comparison of the explicit intentions and purposes for which the building principles have been introduced, with the spatial consequences and the logical social implications that the rules may entail.

The analysis of the outputs of the generative model has shown the effects of the embedded local rules on the global structure of the systems. It has shown that the y joining rule combined with the y sliding, increases the axiality of the systems, which become more integrated and more directly accessible from the outside. The integration structure tends to increase its links to the outside of the morphology. On the other hand, the axial dimension of the system represents, by definition, its most global organisation, since axial lines can only extend farther away. Therefore, the axial organisation may be seen to bring local parts closer together and facilitate access of the settlement from the outside (Hillier B., Hanson J., 1984, p. 95). Consequently, the y joining rule produces morphologies in which the generative logic is more oriented towards the global level of organisation, that is towards facilitating the accessing of strangers to particular areas and their interfacing with the inhabitants.

The x clustering rule has, however, produced the opposite effect. It introduces more fragmentation in the axial organisation of the systems by increasing the size of the blocks, and as such the systems become more segregated and less accessible from the outside. The integration core tends to concentrate in the middle of the system, creating a highly isolated structure with respect to the outside. In other words, the insistence on x clustering rule is more likely to create morphologies with the tendency to localize the form as the system grows, and in which the generative logic is more oriented towards the local level of organisation, that is towards the female members and their children which are constantly present at the local streets and at their homes.

<u>Explicit intentions underlying the generative rules and their spatial and social implications</u>:

The investigation into historical facts concerning the process of building and urban development has established a framework to identify the justifications and the explicit reasons underlying the building principles. For instance, the intention behind the high densities of land development, expressed in the rule x clustering are environmental, economic and defensive.

i- environmental: the hard climatic conditions of the Sahara imposed a dense packing of buildings which reduces the surfaces directly exposed to the sun and therefore provide more shade and creates more comfortable environment (i.e. Hakim B., 1986, p. 66).

ii- Economic and Defensive: The shortage of land for building, as a consequence of walled settlements for defensive purposes, imposed high densities of development, that is the use of the whole plot of land for the building. The pressure of growth and the need for extra space for construction led to the building of rooms spanning the streets.

The investigation into historical facts has also shown that the reasons behind the sliding rule of the y cells, is to avoid the creation of visual corridors between opposite buildings. This rule, it has been shown, increases the axiality of the system (see diagram p. 304. In other words, the mechanism by which privacy is obtained is not through clustering and thereby investing in the more localized spatial relations as believed by many scholars (*), but mainly by contributing in the more globalizing dimension of the

* The reader is referred to Part One of this report.

spatial arrangement, that is in contributing in the linear development and extension of the open system. The fact that the x clustering rule produces more segregated structures and larger blocks indicate the potentiality of the settlement to create extra spatial relations between the main category of users, i.e. the female members. No social justification relating to the spatial need of the women is attributed to this rule in the Mzab towns.

By clustering the closed units:

It firstly increases the roof connections and therefore increases spatial contiguity between the female members. The only constraint related with the roof usage in the Mzab towns, is that no man is allowed into it during day time, and it is intended for drying food, cloth landering and for sleeping during the hot nights of summer. The social rules, that are global in scope, do not specify that in practice the women in the Mzab towns should use the rooves or the segregated parts of the street system for their socializing. In other words, there is a certain level of indeterminacy and un-specification about the impact of the building principles of aggregation.

And secondly, it increases the inaccessibility of the streets from the outside; the integration core tends to become more internal and isolated, creating therefore highly isolated areas which can be used by the more restricted category in mobility terms: the women.

The negotiative relationship between the two generative rules, y joining and the x clustering, seems to have profound and strategic implications on the system of relations between the categories of users, and especially between men and women. The more there is insistence on y joining, the more the overall spatial structure is likely to be geared towards the global organisation, that is towards facilitating the accessibility of strangers and therefore encouraging their interface with the male population, and the more the women will be likely restricted and confined to the interiors, and the more they would be spatially isolated from each other. In this case other means than space would be required if they have to exist as a cohesive group. But, the more there is insistence on x clustering, the more the overall spatial structure is likely to be geared towards the local level of organisation, that is discouraging the accessibility of the strangers and therefore restricting and controlling their interface with the male members to particular areas of the system, the more there will be highly segregated parts, and the more the women are spatially brought together by the increase in spatial proximity (i.e. the continuity of the roof areas), encouraging therefore their contacts, without contravening the separation of the sexes which is the most important global social rule, which is religious in origin.

In Part One, it has been shown that as the separation of the sexes prevails as a social rule, so does the fact that the men should leave the house and the "neighbourhood" during the day and return only on specific hours. The combination of the two social rules, in addition to the spatial properties of the settlement, seems to provide the basis for differential space uses by men and women.

What this chapter has established is the fact that social hypotheses can be better formulated in terms of the generative rules, which also seem to have strategic implications and consequences on the systems of relations within and between the sexes.

This generative approach has opened up a more general question concerning the interpretations often associated with this particular type of settlement: the Arab-Muslim city as referred to in the literature.

SUMMARY TO CHAPTER FIVE:

This chapter has examined the possible relationship between the spatial properties of the towns under study and the underlying spatial rules and processes of urban growth, as well as the social rationale of these rules. By this, this chapter has promoted a spatial way to investigate into the social dimensions of spatial forms by enquiring into the social nature of the generative processes and rules, using a generative approach and also some historical evidence about the nature of development control in these towns. It has been concluded that many syntactic properties observed in the towns in question, may be to a great extent, the product of a greater localization of space structuring, which may be seen to express a means of control of relations between and within the sexes.

CHAPTER SIX AND CONCLUSIONS: THE GENOTYPICAL CHARACTERISTICS OF ARAB TOWNS AND THE RELATIONS BETWEEN THE SEXES

This chapter opens up a discussion by reviewing the research project as a whole in the light of the three types of information generated by the study -descriptive, analytic and generative; in an attempt to see the relevance these have on the theoretical questions of the study, that is the "genotypical" characteristics of Arab towns and the relations between the sexes as reflected in these characteristics. By this, the present chapter aims to draw the final conclusions, using the ethnographic and morphological material presented in Part One of the report together with the analytical and generative evidence in Chapter Four and Five.

The descriptive section of the study has established morphological differences between the towns at three levels of space organisation; at the level of the town fabric, the house and the terraces. At the level of the urban fabric, the differences between the towns can be summarized in terms of the compactness of the overall form, the regularity of the street network and the street coverage by buildings. In these terms, Ghadames differs from the other towns; its fabric is divided up into distinct small entities, and the streets with the exception of one quarter, are entirely covered up forming irregular "tunnels" underneath the four-storey buildings. In each of these quarters, masonry benches are built along the main streets. Ghardaia and Beni Isguen present a much more compact and massive form, and the streets which are occasionally covered up, divide the urban fabric into irregular blocks of various shape and size. Only the streets in the vicinity of the market and the market place itself are furnished with built-in masonry seats for men. Conversely, the streets of El Oued form a much more regular grid and lack any street furniture.

From the point of view of house layout, the main difference between the towns resided in the distribution of male-female spaces with respect to the outside and to the terraces. In Ghadames, except Bellil, the female's spaces are located at the upper floor, and have a direct access from the ~~rooves~~ roofs. In the houses of Ghardaia and Beni Isguen, the kitchen and the women's living room are located at ground level, away from the terraces. The male quarters on the other hand, are directly connected to the streets. The houses of El Oued showed no specifically designated spaces for female's use except for the kitchen; and the men's sitting room has also a direct access from the streets.

From the point of view of the terrace configuration, the major differences observed between Ghadames and the Mzab towns are that in these latter, the links at roof level are restricted only to the level of the block; while in Ghadames the links are systematically built throughout the quarters and the spaces for circulation in the terraces are clearly demarcated by physical boundaries.

Part One has also identified the different practices in these towns in terms of space use by men and women. In Ghadames, street uses are mainly associated with men. This is a significant difference from the Mzab towns where men are more associated with the areas around the mosques and the market place. Differences in the way the terrace system is used in the Mzab towns and Ghadames have been also reported. In the former, the usage of the rooftops is more incidental and restricted to smaller areas; while in the latter, the terraces are used at a more regular basis and much more extensively; in El Oued, neither the street nor the roof social activities of women have been noted.

The consideration of these descriptive facts has led to the suggestions that there may be a relationship between the spatial structure of the towns and these differential uses, and also between the spatial structure of the towns and the differential form of the terrace system.

Part Two has shown the presence of regularities in the spatial organisation of the three towns with the terrace system in the full sense or only partially. Throughout the cases, whether looked at from the point of view of the organisation of their parts or as a whole or according to the different versions of representation, the high level of segregation in the street structure prevails. The other consistent result and characteristic invariant to these spatial forms is the way in which the spatial parameters correlate with each other. All cases have exhibited a weak relationship between integration and connectivity.

Part Two has also demonstrated strong variations between these systems, and these can be summarized in terms of both the pattern of growth and the global organisation. The analysis of the local and global systems of Ghadames has shown that this town grows by keeping the mean and maximum connectivity constant, and increasing its level of segregation, suggesting therefore that the system of Ghadames seems to grow additively without restructuring the whole. But, Ghardaia grows by improving the maximum connectivity, while keeping constant its level of segregation; and Beni Isguen grows by improving both its maximum connectivity and its level of integration. These variations in the measures as the systems increase in size, denote underlying variations in the processes of growth for these towns.

The morphological differences observed in these towns have been amplyfied by spatial differences in terms of global organisation, and the arrangement of the main circulation lines. In the small systems of Ghadames where the terrace system is in a full form, the integration cores take a much more covering pattern. For Ghardaia and Beni Isguen where the terrace system is only in a partial form, there is a clear regionalization in the global structuring of space, and the cores are much more non-covering; while in El Oued where there are no terraces, the system presents a grid-core type. Therefore, these results suggest a possible relation between the differential forms of the terrace system and the spatial structure of the towns.

On the other hand, a close correspondence has been noticed between the social uses of space by men as described in Part One, and the spaces covered by the integration cores and the main circulation lines given by the simulation. In most cases, and according to the different versions of representation or the different stages of growth, the integration cores intersected the spaces and areas mainly used by men. The only exception is the mosque in the large system of Beni Isguen, which remained segregated from the integration core and did not figure on the popular route resulting from the simulation. These results suggest then a possible relation between the observed space uses and the spatial structure of the towns.

The analysis of the generated systems based on local rules of aggregation has shown that most of the numerical properties and their interrelationships identified in the towns with the terrace system have been reproduced, although to a varying degree, in the simulated systems. Similarly to the real towns, the generated systems have showed to be highly segregated with a poor level of intelligibility, suggesting then that the spatial fabric as described by the numerical properties can be seen to a certain extent, as the result of a more localized process of growth. The variation of the generative parameters has introduced variation in the numerical properties of the systems, and the results have shown that the x clustering rules (or an x-led mode of cell aggregation) increases the level of segregation and the size of the blocks; while the y joining parameter improves the level of integration of the systems. These results may explain the variations observed in the pattern of growth of the towns under study, and suggest also a possible relation between an x-led mode of aggregation and the development of the terrace system.

Moreover, the analysis has shown that the regionalization of the urban structure and the non-covering core type observed in the global organisation of the Mzab towns, has been consistently reproduced by the simulated systems. Therefore, the non-covering core type and the regionalization of the town structure can be seen to originate from the localization in the structuring of space.

<u>The first general conclusion</u> of the present research is that the global properties of the spatial configura-

tions can be seen as the by-product of the nature of the spatial fabric. Therefore, a strong relation has been established between the nature of the spatial fabric of urban systems and their global organisation.

Chapter Five has demonstrated how such regularities as described above, can arise purely and simply from a more localized process of building aggregation. It has been shown that both, the distinctive properties of the urban fabric and the regionalization in the global organisation, depend to a large extent, on the urban development process that operates on local rules of building aggregation, applied as restrictions on an otherwise random process. This result is far from obvious and leads to the second general conclusion which is: the global structuring of space in these urban systems is governed, to some extent, by the development process and the nature of the rules followed in the building activity. Therefore, a strong relationship has been established between the global level of spatial organisation of urban systems and their underlying generative rules.

The consideration of the socio-descriptive material together with the results of the analytic and generative studies, has led to the formulation of a provisional thesis regarding the spatial structuring of these towns and the way it relates to the spatial uses by different social groups, and especially by men and women. The regionalization observed in the global organisation of these towns may be associated with the controlling of movements of strangers in the systems and their interface with the male-inhabitants. This regionalization has been shown to derive from a more localized process of growth. Therefore, the emphasis on the control of local spatial relations in space structuring may be seen as a spatial device in introducing control on strangers. By the same token, the regionalization in the structure of the town creates by definition highly inaccessible zones especially from the point of view of the strangers. The development of the "zenka society" for the women as described in Chapter Two, can be then attributed to this characteristic global organisation, only because these social activities at the "zenka" are first, not recognized as a right by the social system and therefore cannot be seen to result from some social rules of space classification; and second, they depend to a great extent, on spatial proximity and the absence of men. The male residents are kept out of these areas through the social ritual which requires the men to leave their homes during particular hours of the day; and the strangers are kept away from these areas by the very nature of the spatial organisation of the town. This argument remains, of course, only hypothetical at this stage, and further research is required to substantiate this claim. But, if this turns out to be the key determinant in the absence of the strangers and the development of the "zenka society" then <u>a relation</u>

would have been established between social factors and the generative process of urban formation and the underlying rules; and in these terms, space in these towns appeared then to be structured in the image of the relations between male and female solidarities.

What this means is that two kinds of knowledge were in fact, required to offer a more plausible explanation regarding the morphological invariants observed in the towns under consideration:

- the common knowledge of historical events and social processes in which these forms have arisen. This type of knowledge would never truly explain the particular morphological features as described earlier.

- and the knowledge that included the idea that the process of urban formation in purely spatial terms, and the underlying local rules would lead to the generation of spatial systems which present resemblance to the towns under consideration, that is systems with large blocks of buildings and many cul-de-sacs, that are highly segregated, poorly intelligible and unpredictable, and present a regionalization in their global organisation. This particular kind of knowledge of the relation of implication between local rules and the properties of the spatial forms is necessary to a proper explanation and a full understanding of the settlement morphology.

It follows from this, that if the way in which the towns grow is understood through the identification of the underlying generative process and spatial rules, their social potentials become then more distinct and conspicuous.

What seems to be a useful contribution of the present study is that it has suggested a new basis to open up questions about settlement forms and their relation to social factors, using mainly an architectural approach.

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APPENDIX 1: DESCRIPTION OF THE COMPUTER PROGRAM

THE MAIN PROGRAM:

The principle of a cellular automaton is that, starting from a known state T, a set of cell allocations is made and the counter increased to T+1. Given the state at T+1, new allocations are made and so on until some arbitrary state Tn is reached. This is represented in the program by a single loop. Each pass through the loop generates two random numbers (using Basic's function RND).

If the initial parameters for joining are PX and PY then at any state T, JX, the first random number is to be compared with PX and JY, the second random number to be compared with PY.

XJOIN and YJOIN are the two boolean variables which take the following values:

If JX <= PX then XJOIN is set to TRUE

If JY <= PY then YJOIN is set to TRUE

Otherwise they are set to FALSE.

The program then uses the two variables XJOIN and YJOIN to determine which mode of allocations to choose as described in the following:

SEED (x) REPEAT (for each T)

IF NOT XJOIN AND NOT YJOIN then:

(that means if x-x and y-y joining are set to FALSE)

Place a new x cell randomly on the screen, followed by a new y cell next to it.

IF NOT XJOIN AND YJOIN then:

(that is if x-x joining relation is set to FALSE and y-y joining is set to true)

Choose an existing y cell to place a new y cell next to, and then a new x cell next to this new y cell.

IF XJOIN AND NOT YJOIN then:

(that is x-x joining takes the value TRUE, and y-y joining takes the value FALSE

Choose an existing x cell and place a new x cell next to it (if possible maximising the number of x-x adjacencies with existing cells). Then place a new y cell next to this new x cell.

IF XJOIN AND YJOIN then:

Choose an existing x-y pair and place a new x-y pair such that both new cells are adjacent to the old ones of the same type.

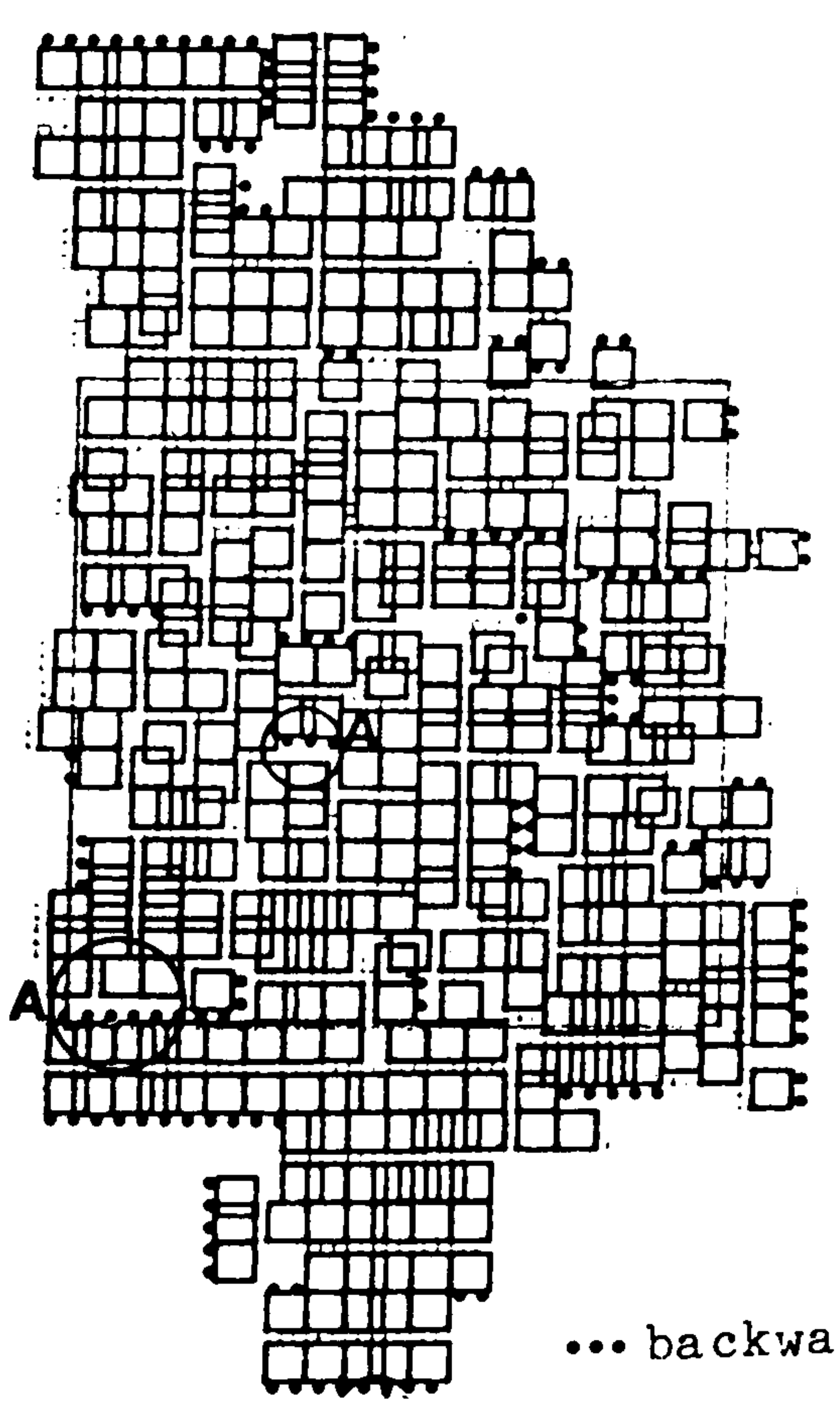
UNTIL the coordinate list is full.

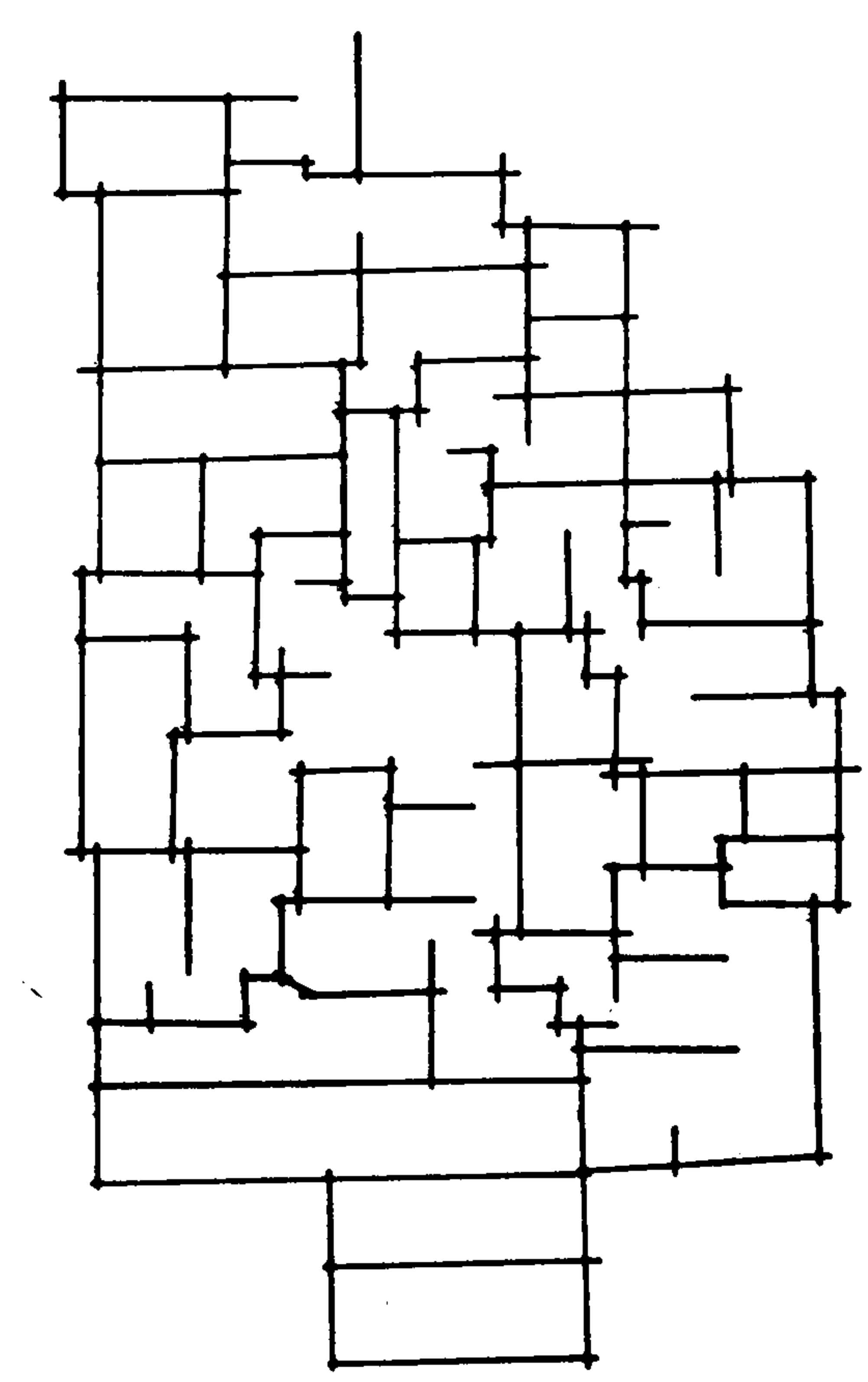
Clearly only one of these four logical relations can hold at any one state T, and it is not automatic that any particular allocation attempt will succeed. If a chosen allocation is unsuccessful then no allocation takes place for that iteration.

NOTE:

The interpretation of the outcome morphologies into axial representation uses both the open spaces created by the rules and unallocated cells, since in real situations the continuous structure of open space includes parts that are not constituted by building entrances. However, this is only the case in so far as the rules of allocation are first checked against; such as the rule which prevents closed cells having open cells on opposite sides (see p. 302). This rule is implemented in the computer programme by the introduction of the backwall cells (see example below), which are shown only on the computer screen but not on the print-outs. These backwall cells, which are Ix3 blocks, are not taken as part of the open space, since they have already been excluded by the rule. This only applies to the layer of backwall cells, not to any spaces which may be adjacent to them. In cases where there is more than one layer of cells as shown in A, the unallocated layer is included. On the periphery, axial lines are drawn by joining segments of constituted open spaces.

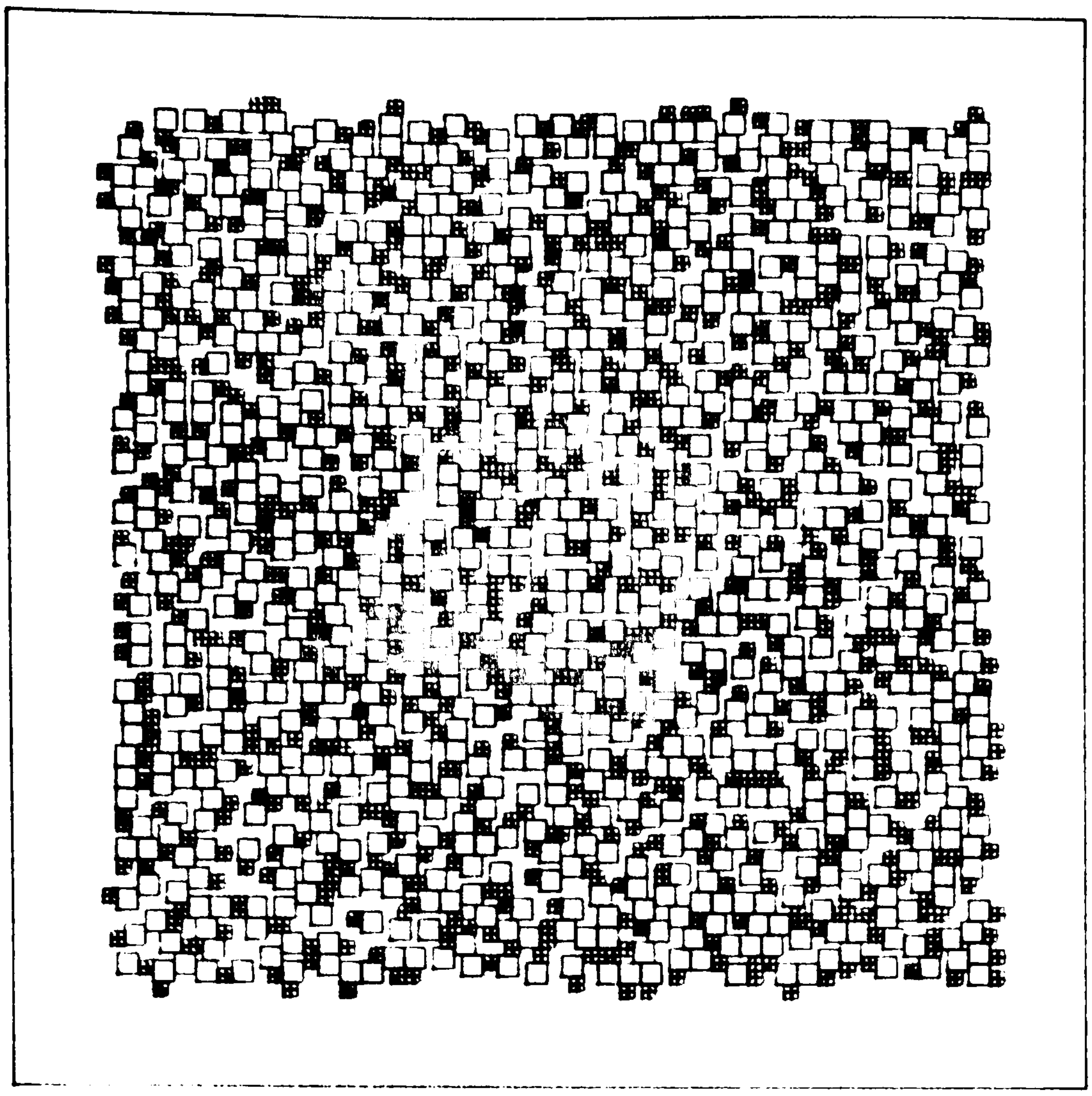
The procedure of interpretation is admittedly rather tortuous, and ambiguities can occur -for example, in deciding visually if a line strikes a vertex or passes it by. However, experience has shown that minor differences in the axial interpretation of layout will make a relatively small impact on the essentially statistical properties of layouts under investigation here.



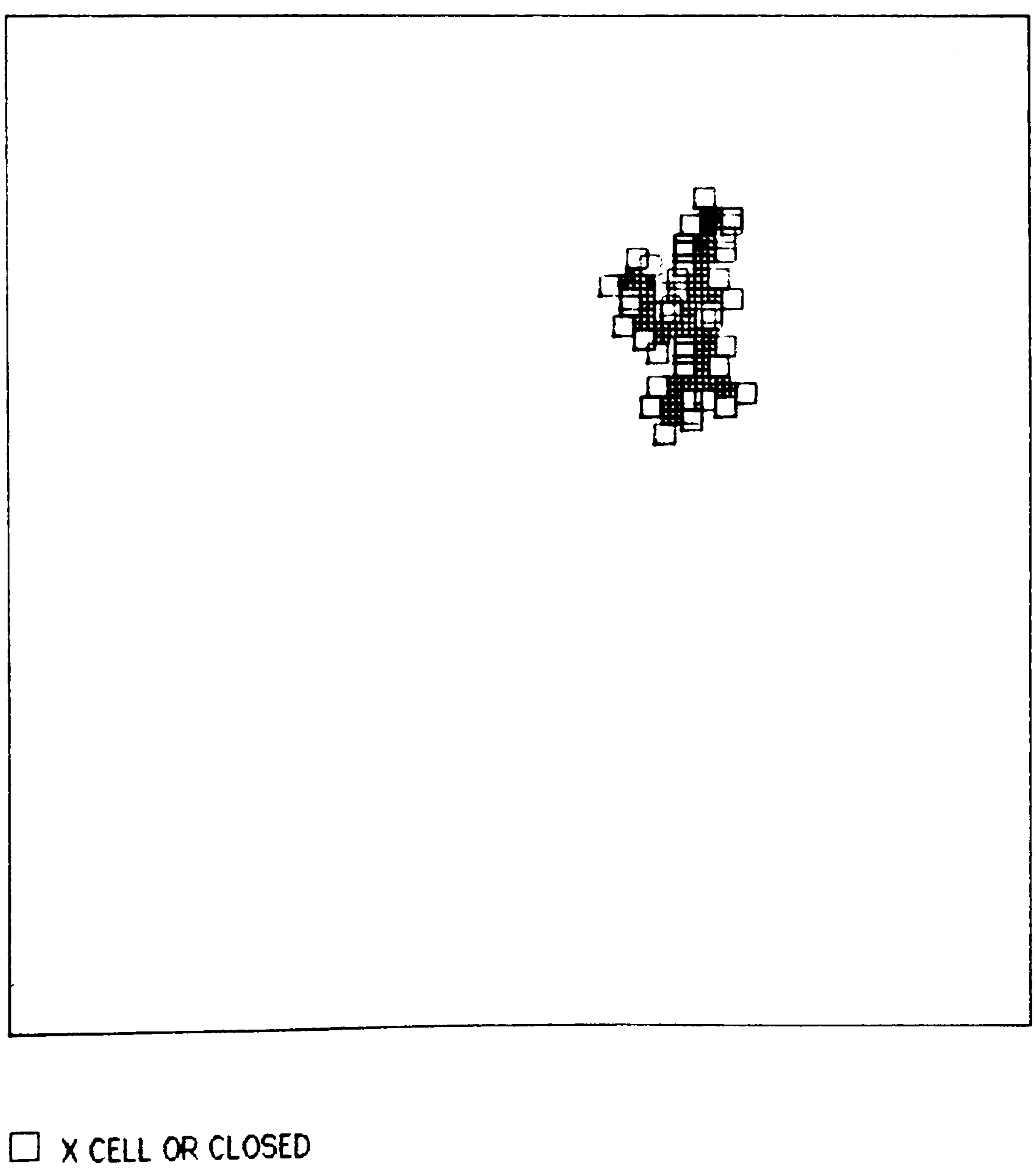


••• backwall cells

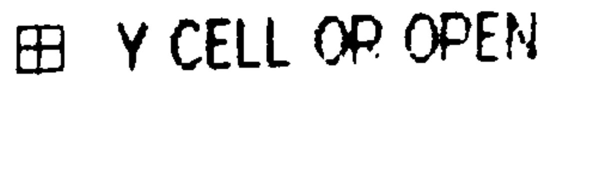
APPENDIX 2: COMPUTER GENERATED MORPHOLOGIES

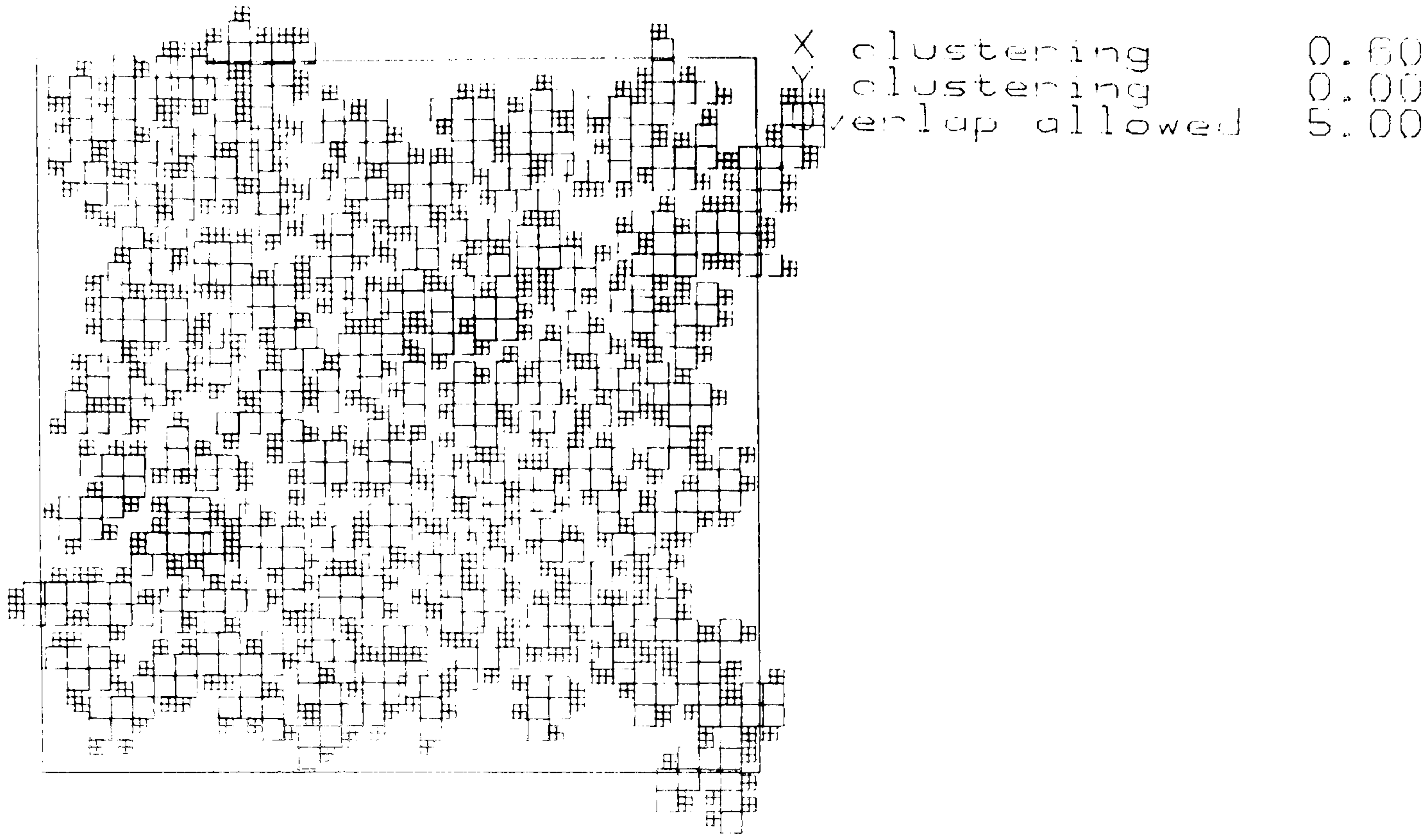


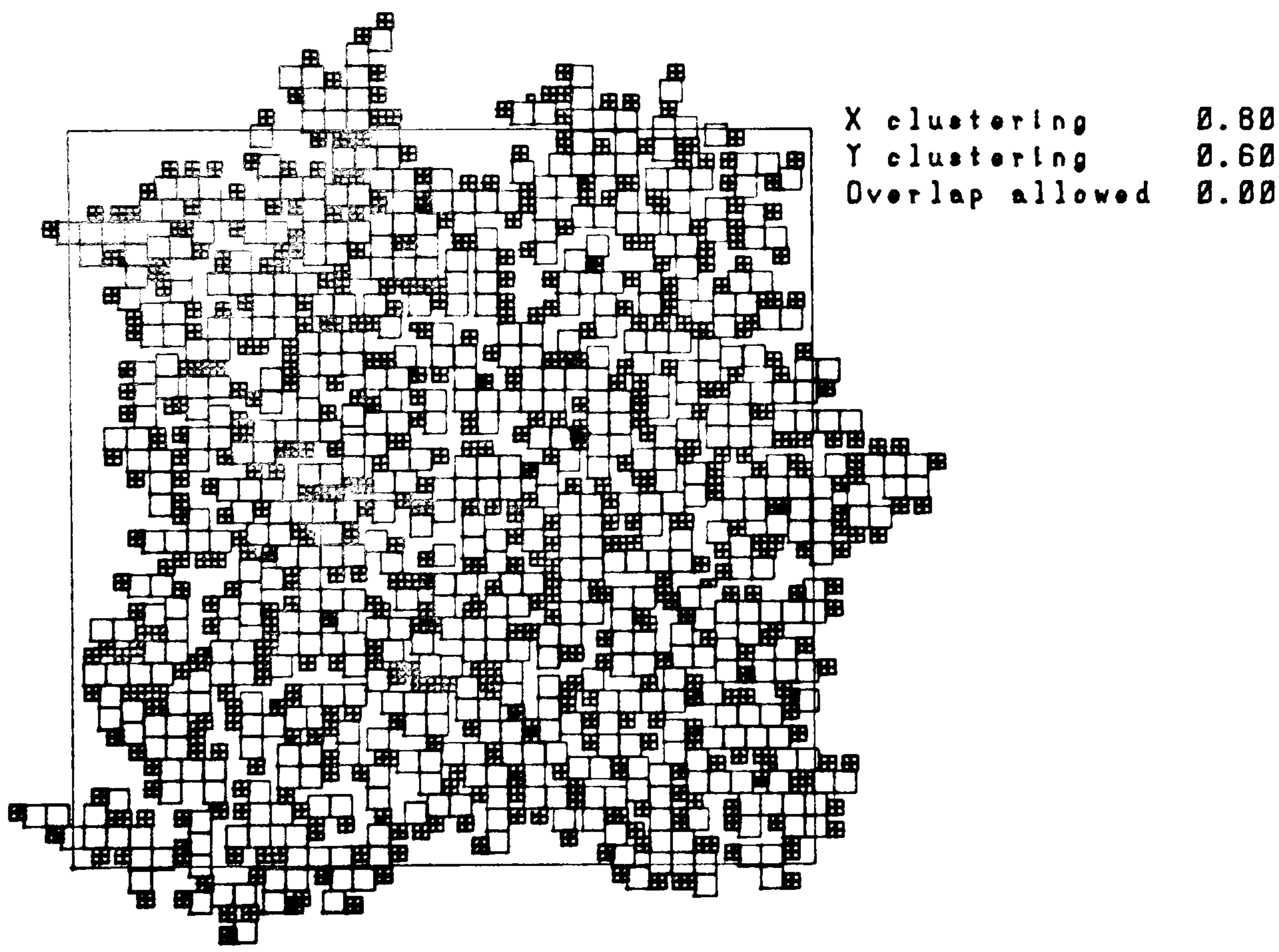
X clustering 0.00
Y clustering 0.00
Overlap allowed 0.00



X clustering 0.00
Y clustering 1.00
Overlap allowed 9.00

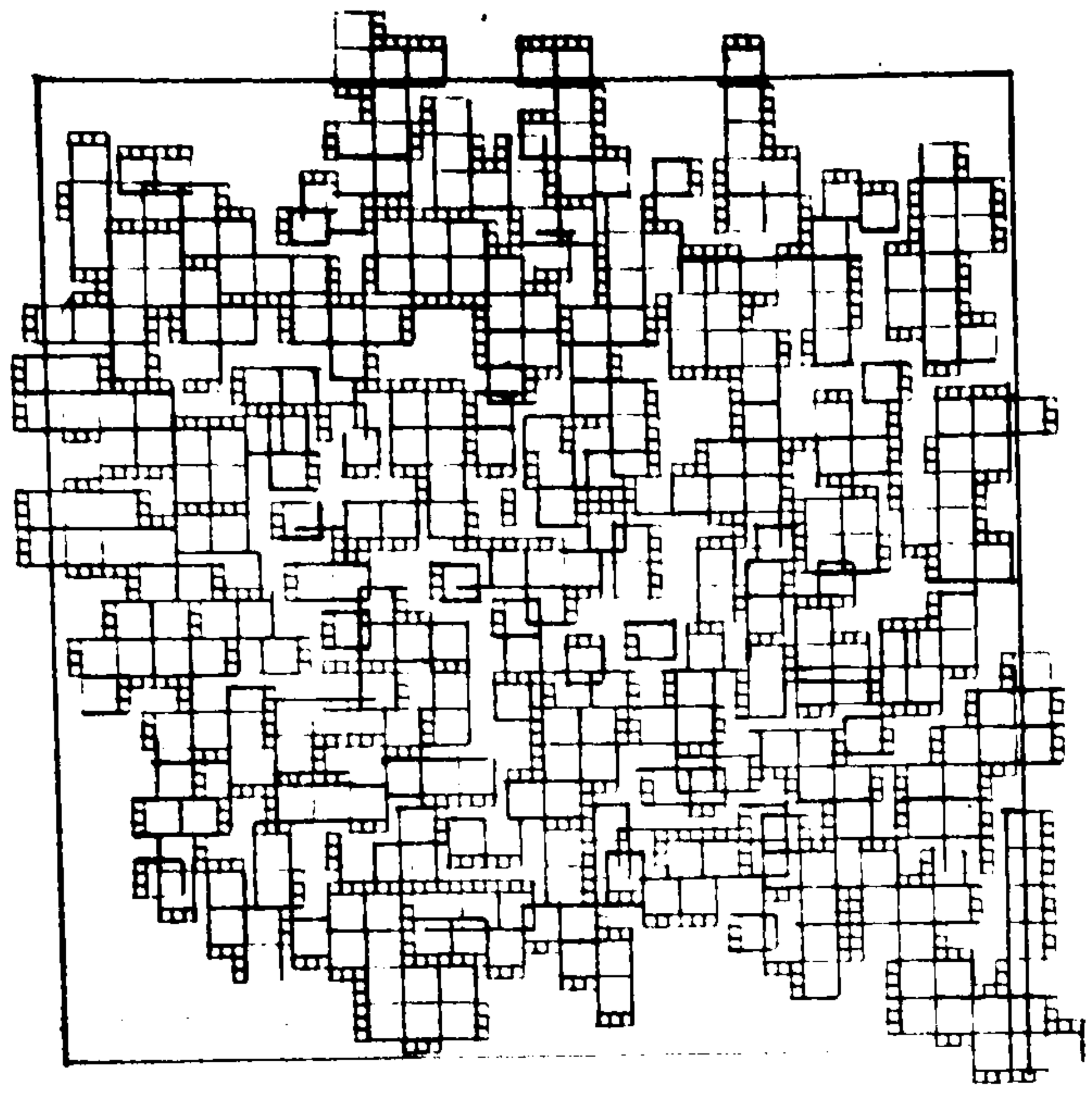


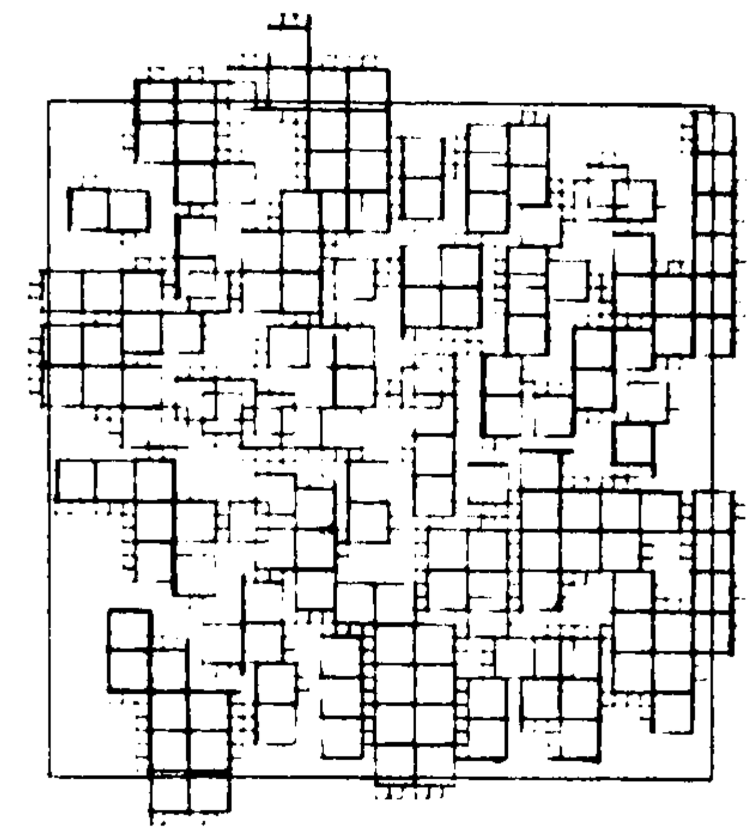


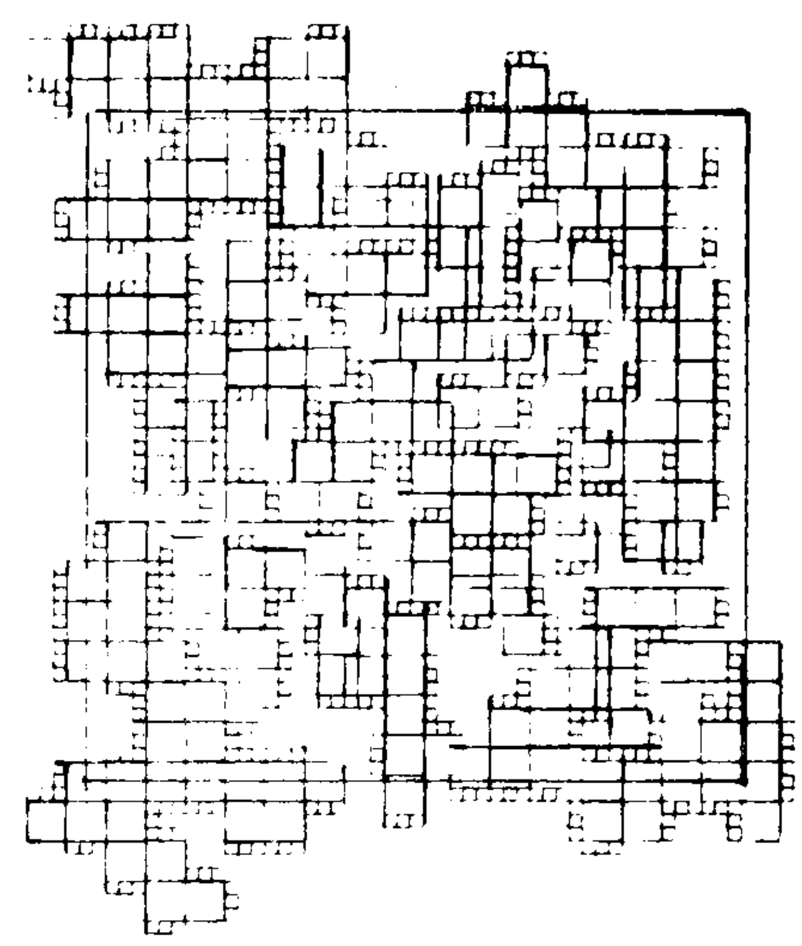


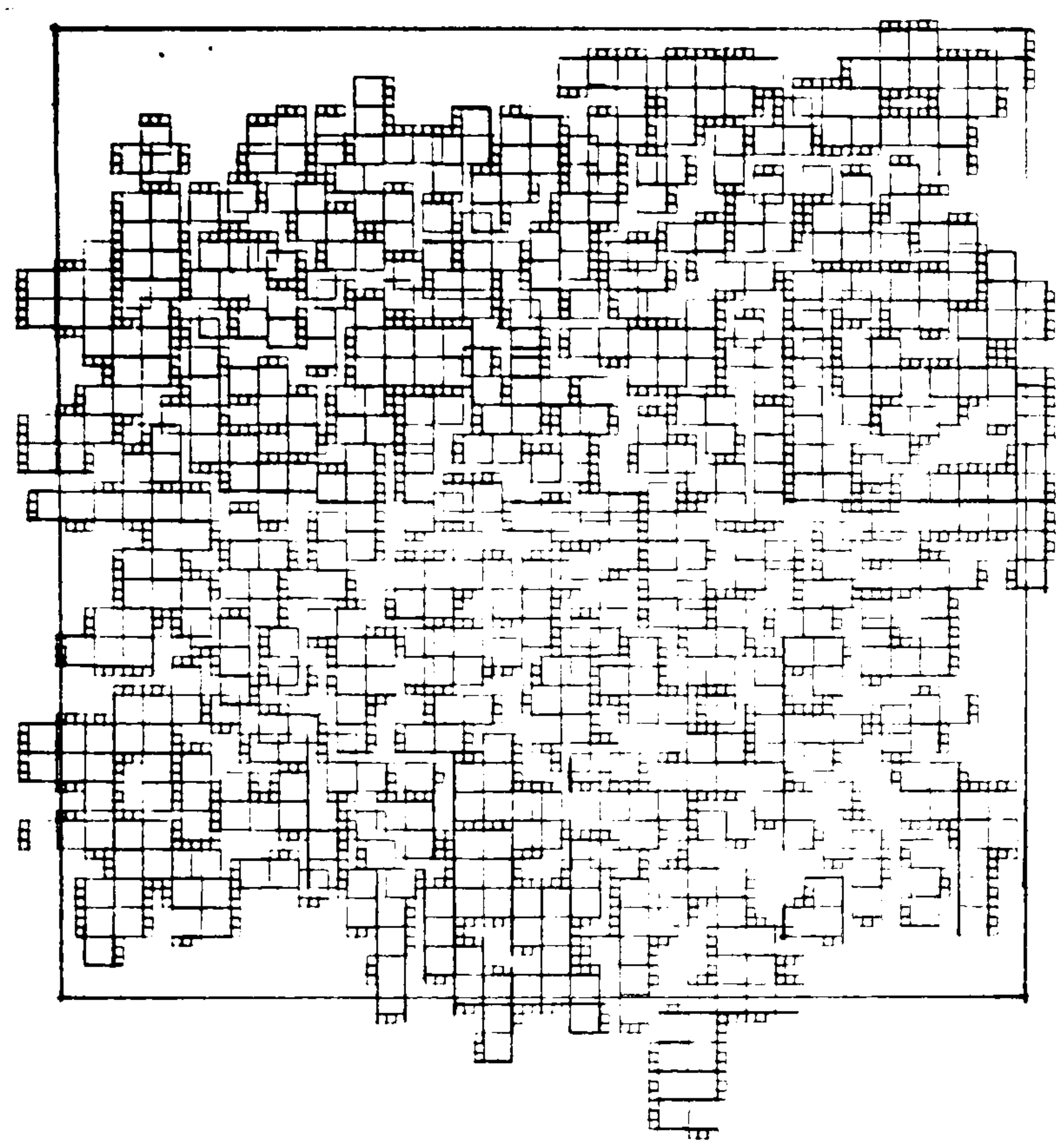
☐ X CELL OR CLOSED

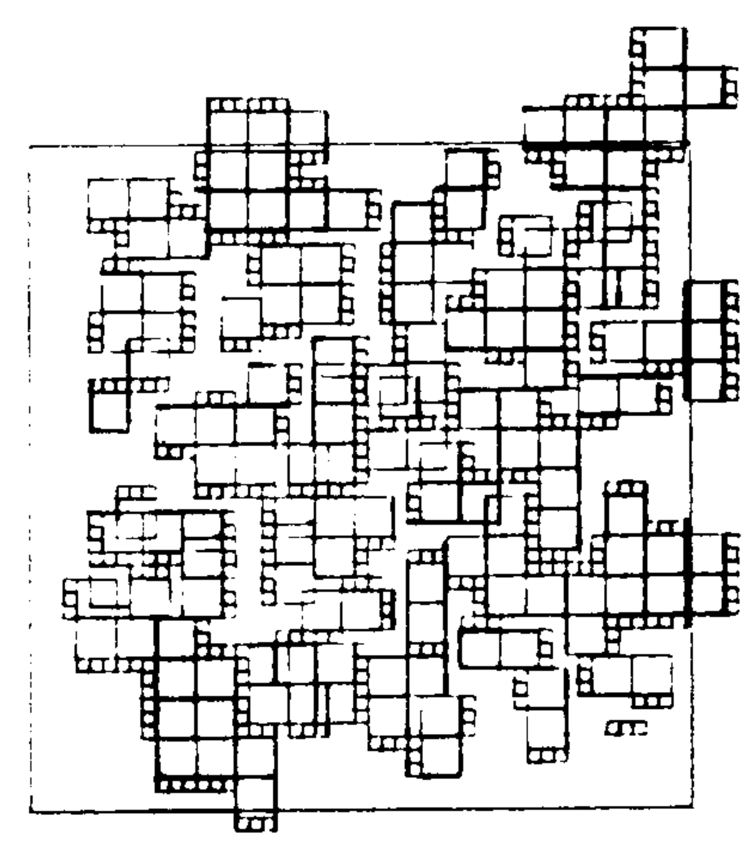
⊞ Y CELL OR OPEN

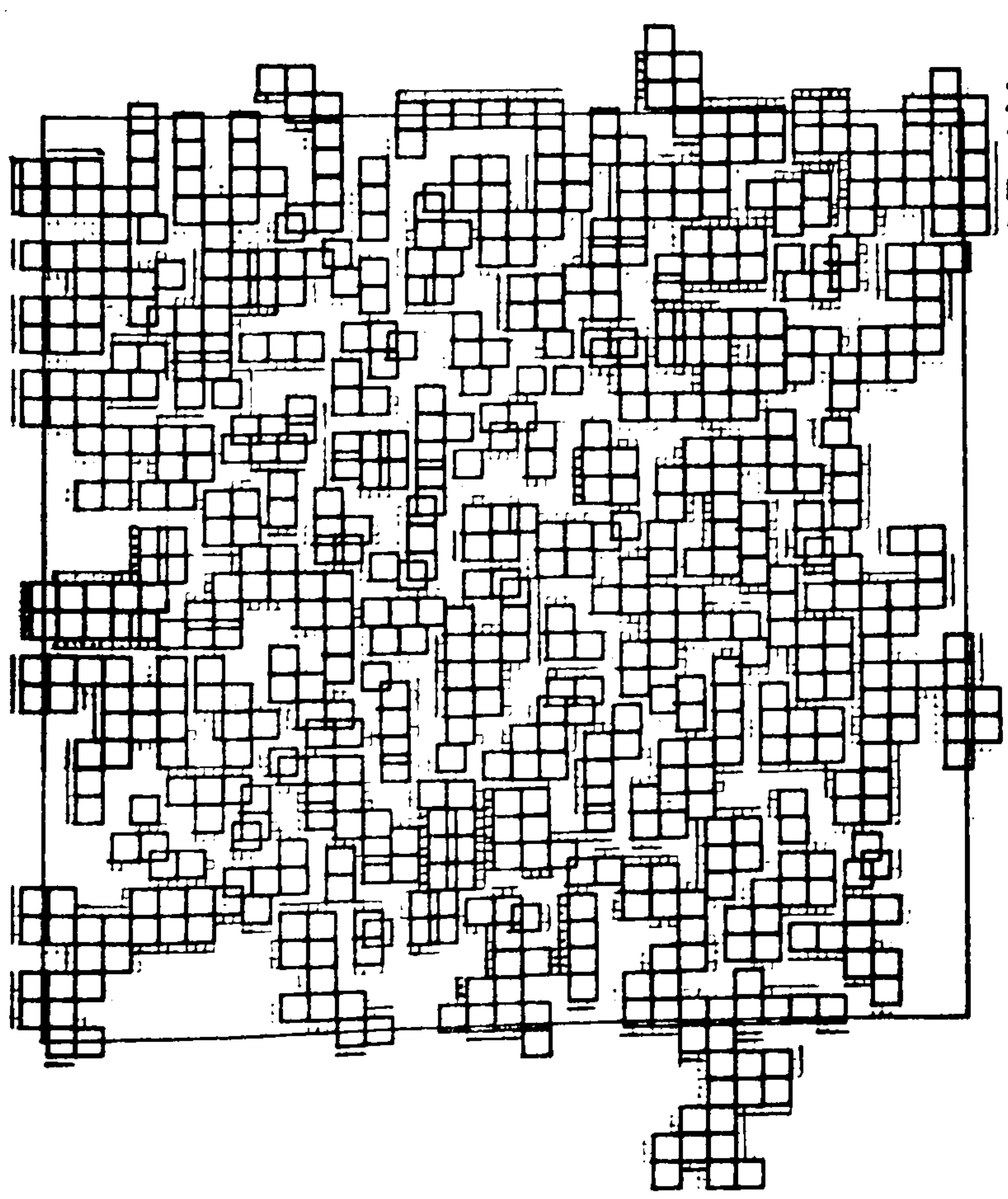



X clustering 0.40
Y clustering 0.00
Overlap allowed 5.00
Y sliding 0.80






X clustering 0.40
Y clustering 0.00
Overlap allowed 5.00
Y sliding 0.80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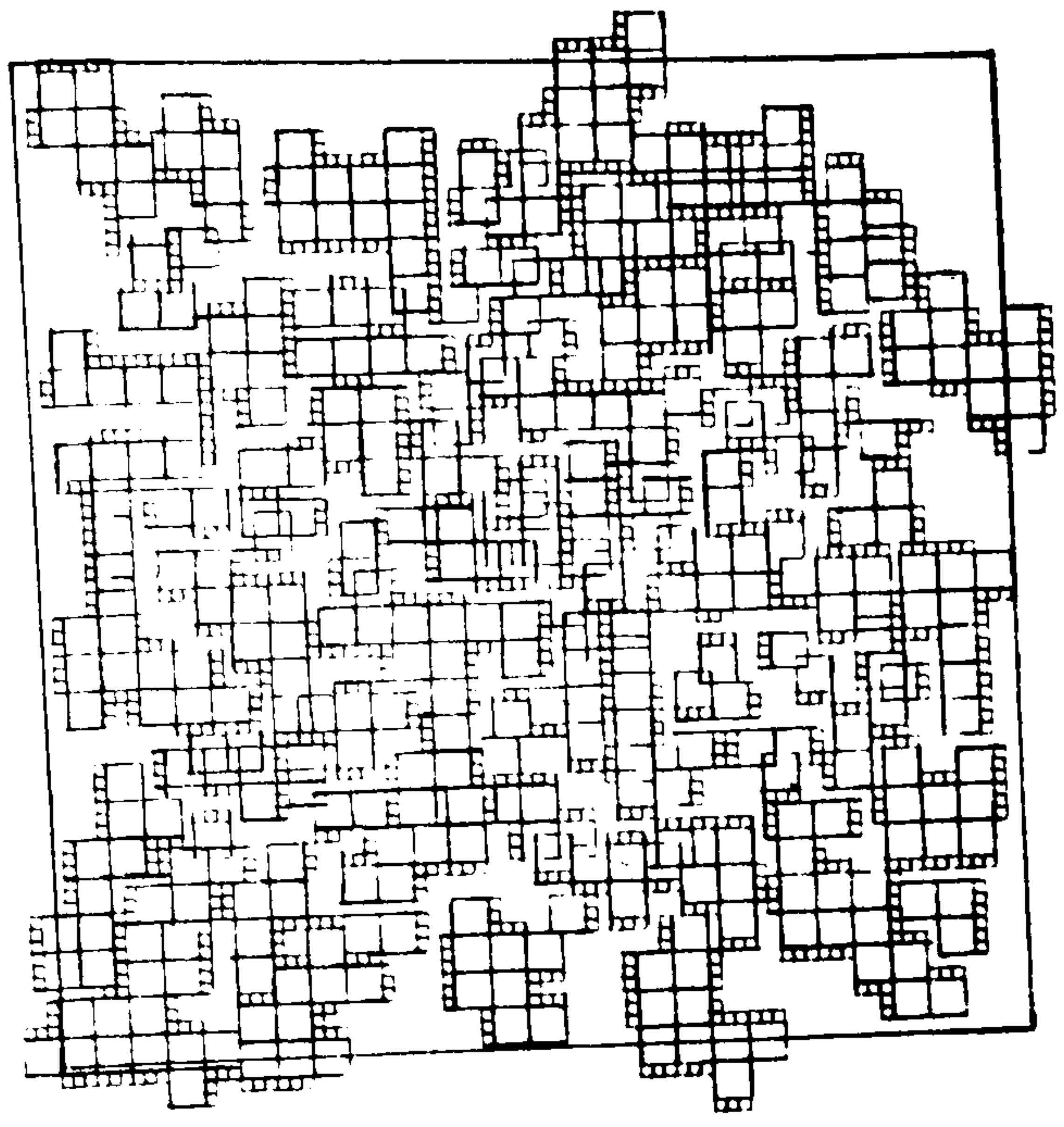
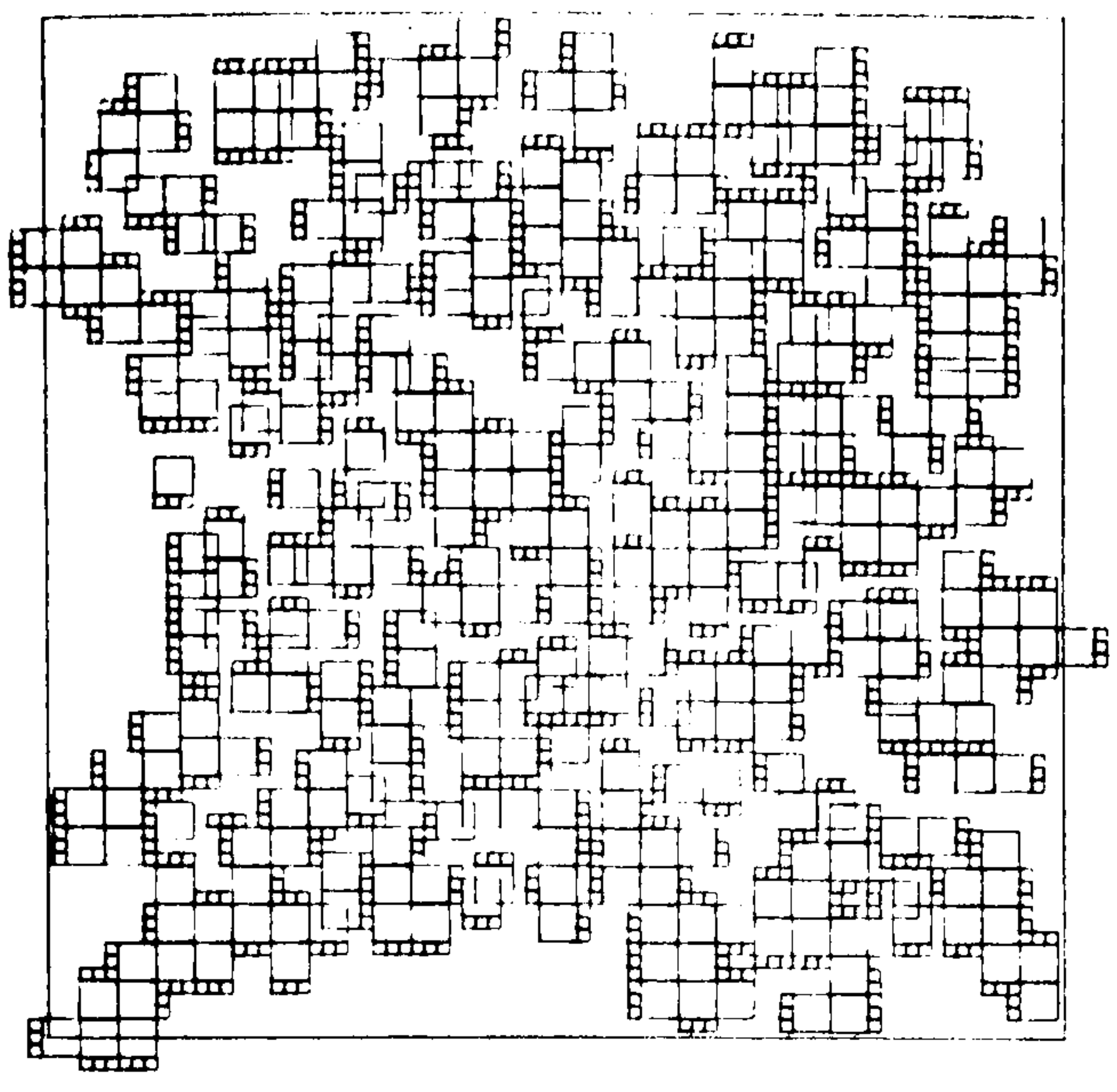
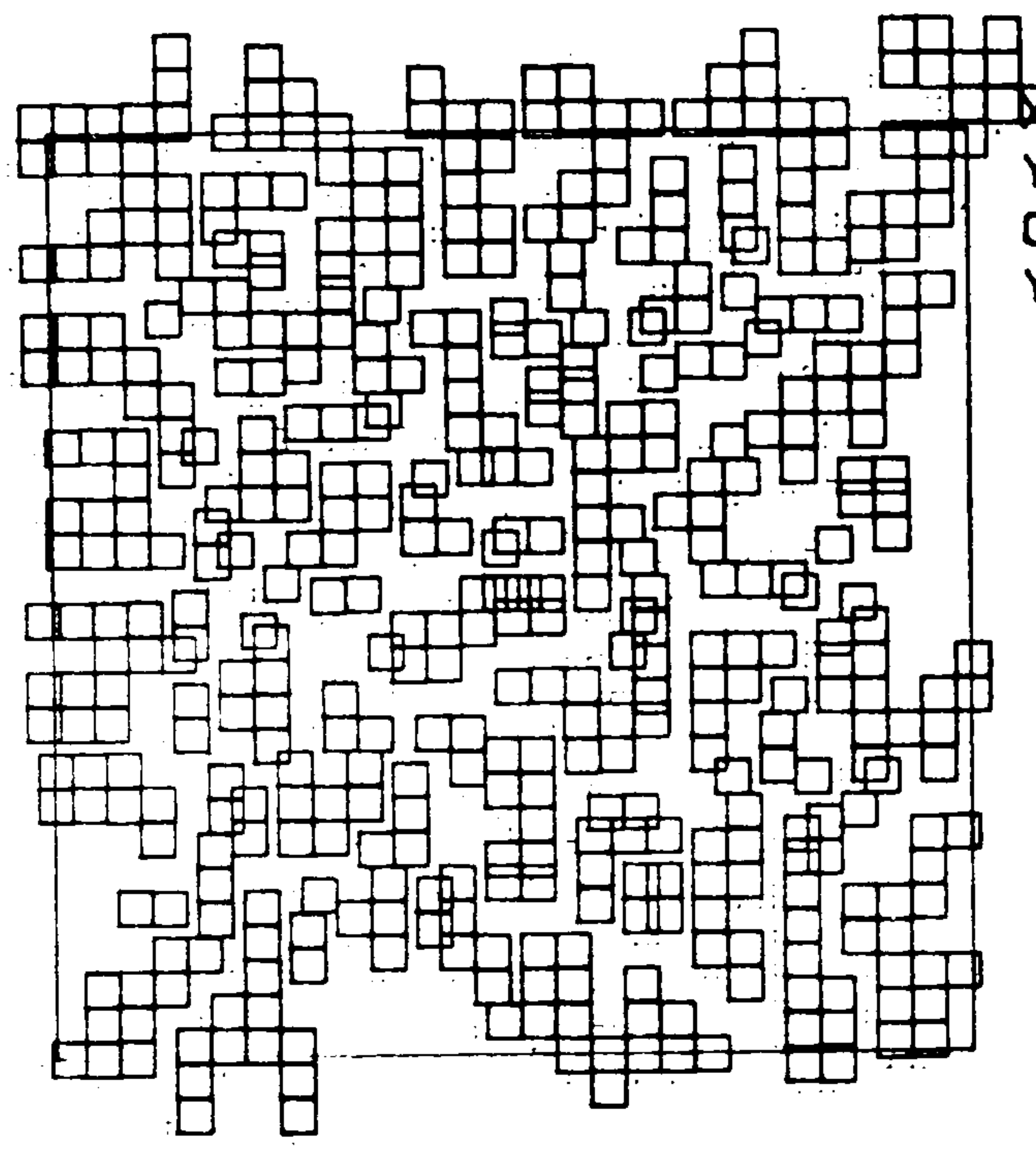
Y clustering 0.00
Overlap allowed 5.00
Y sliding 0.80

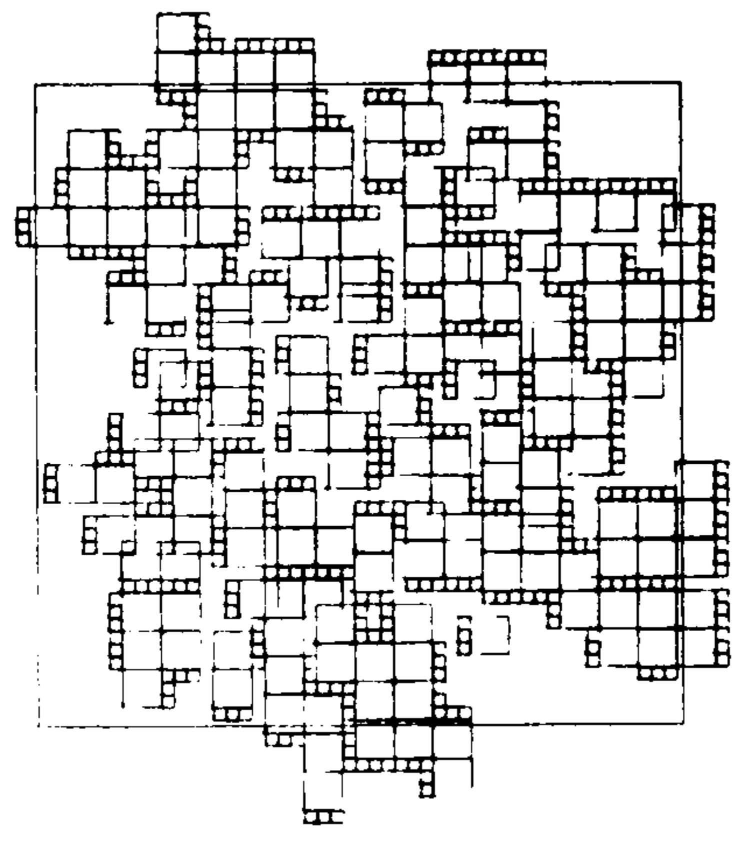




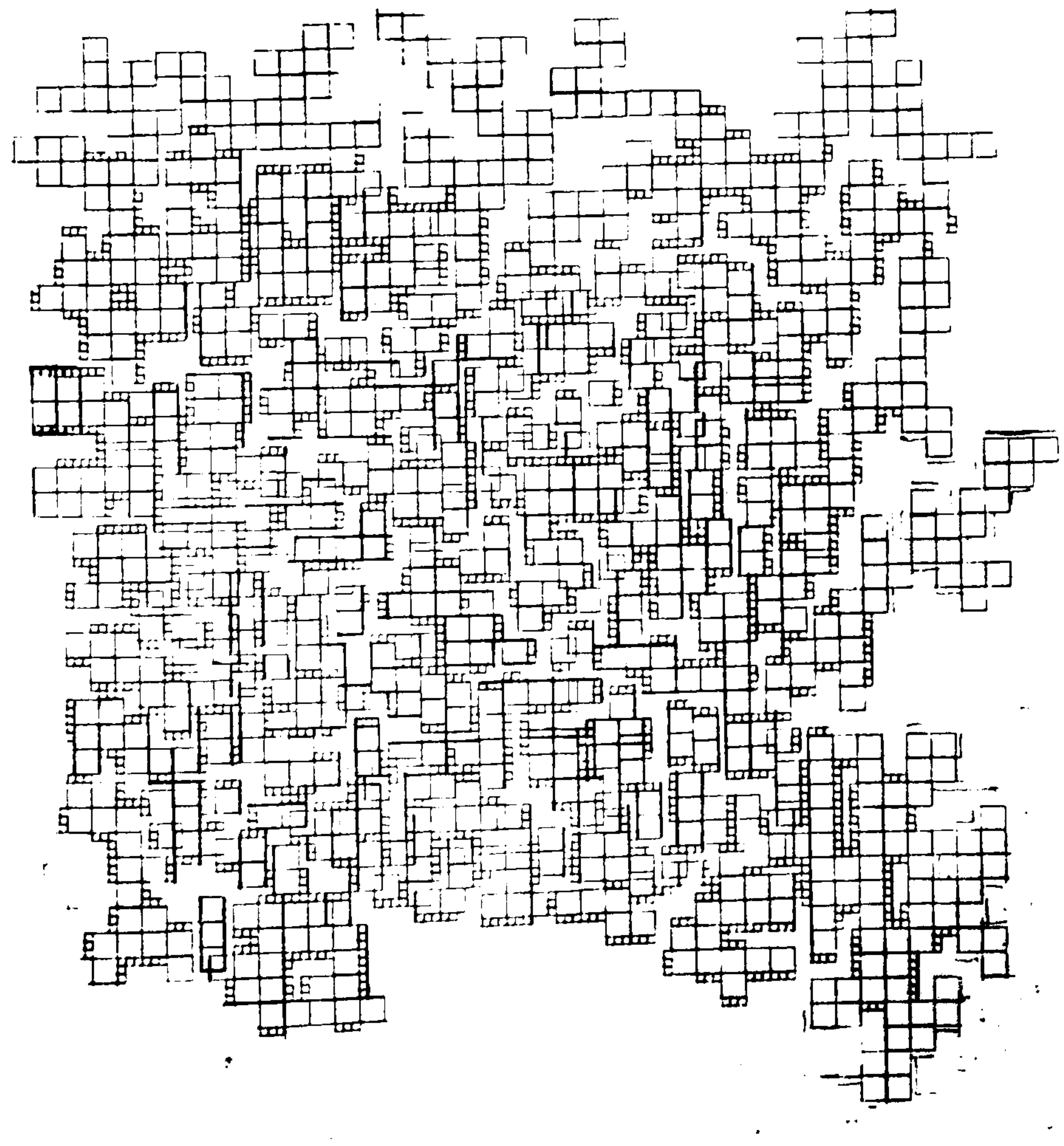
X clustering 0.40
Y clustering 0.00
Overlap allowed 5.00
Y sliding 0.80

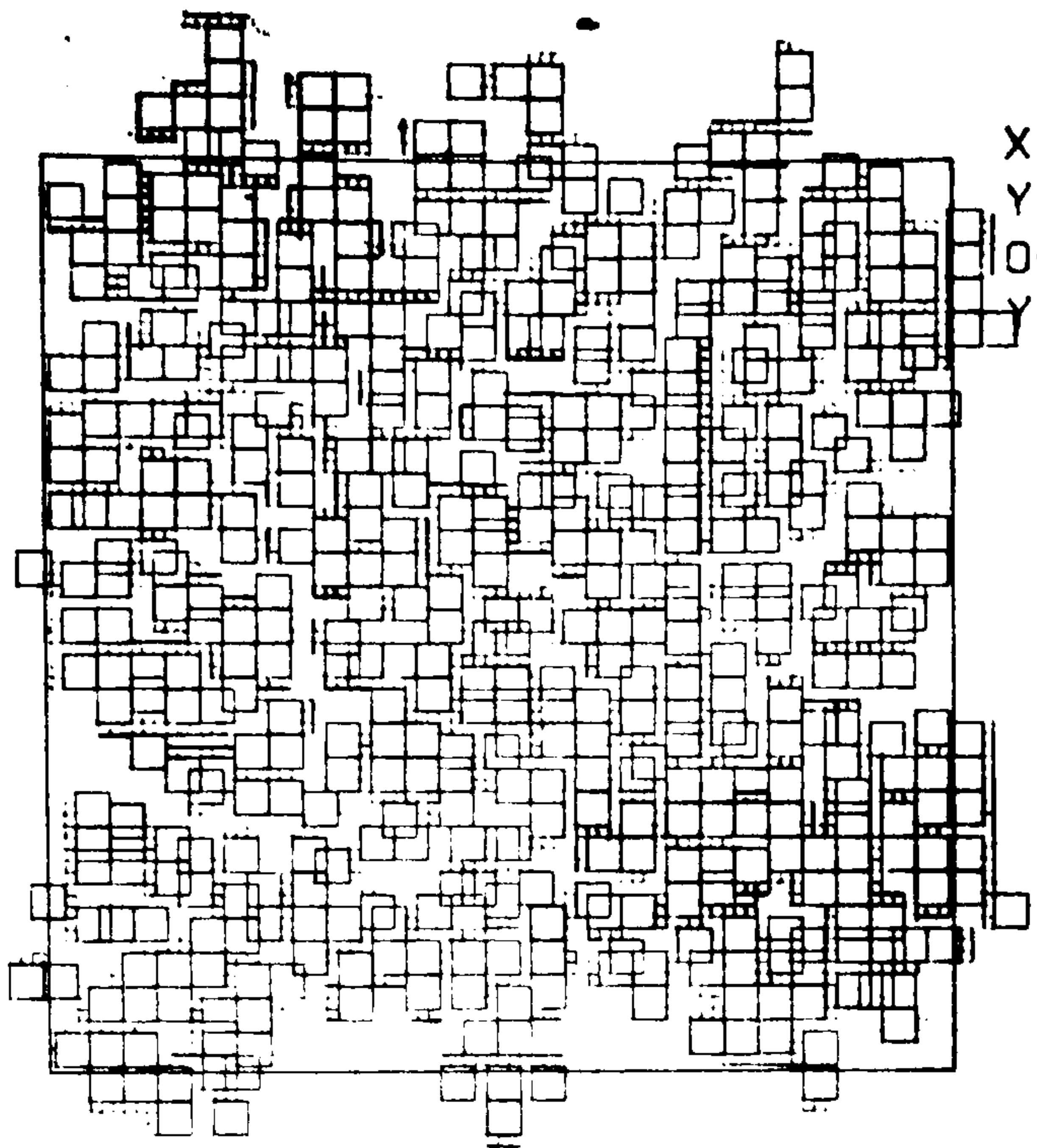


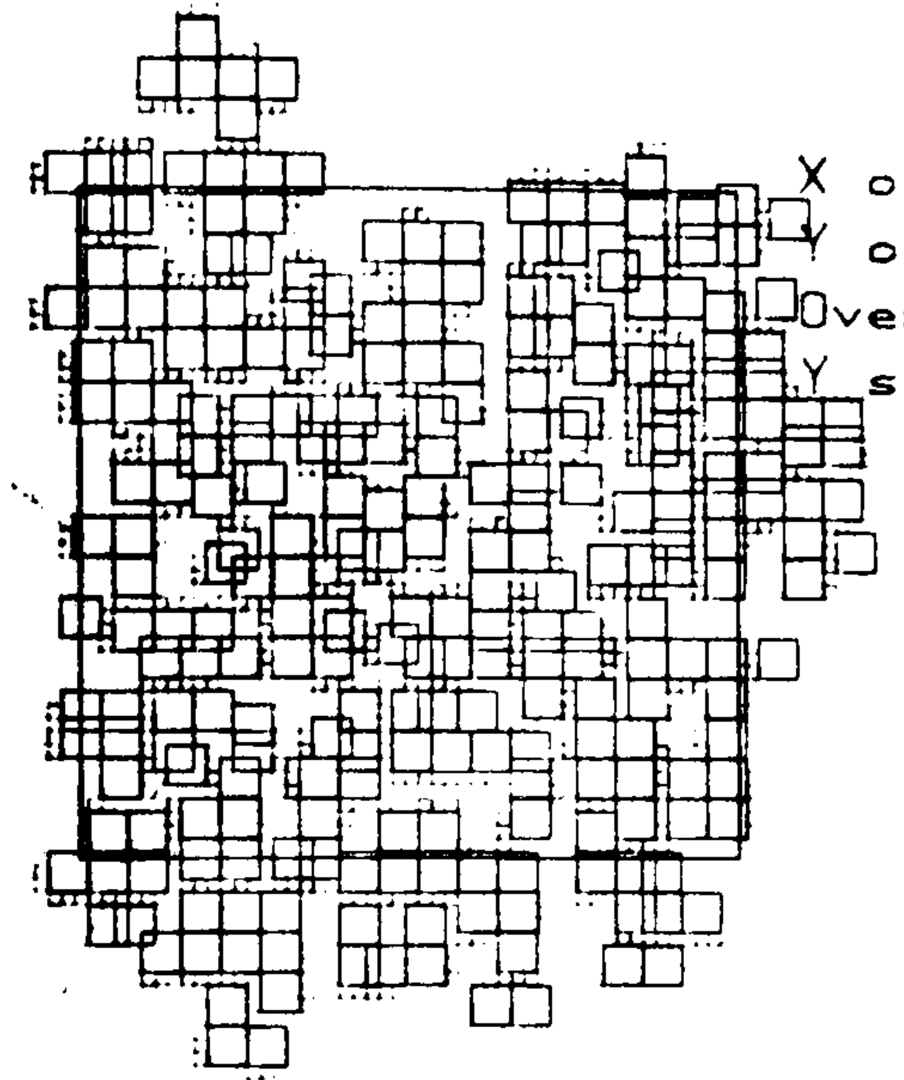
X clustering 0.40
Y clustering 0.00
Overlap allowed 5.00
Y sliding 0.80

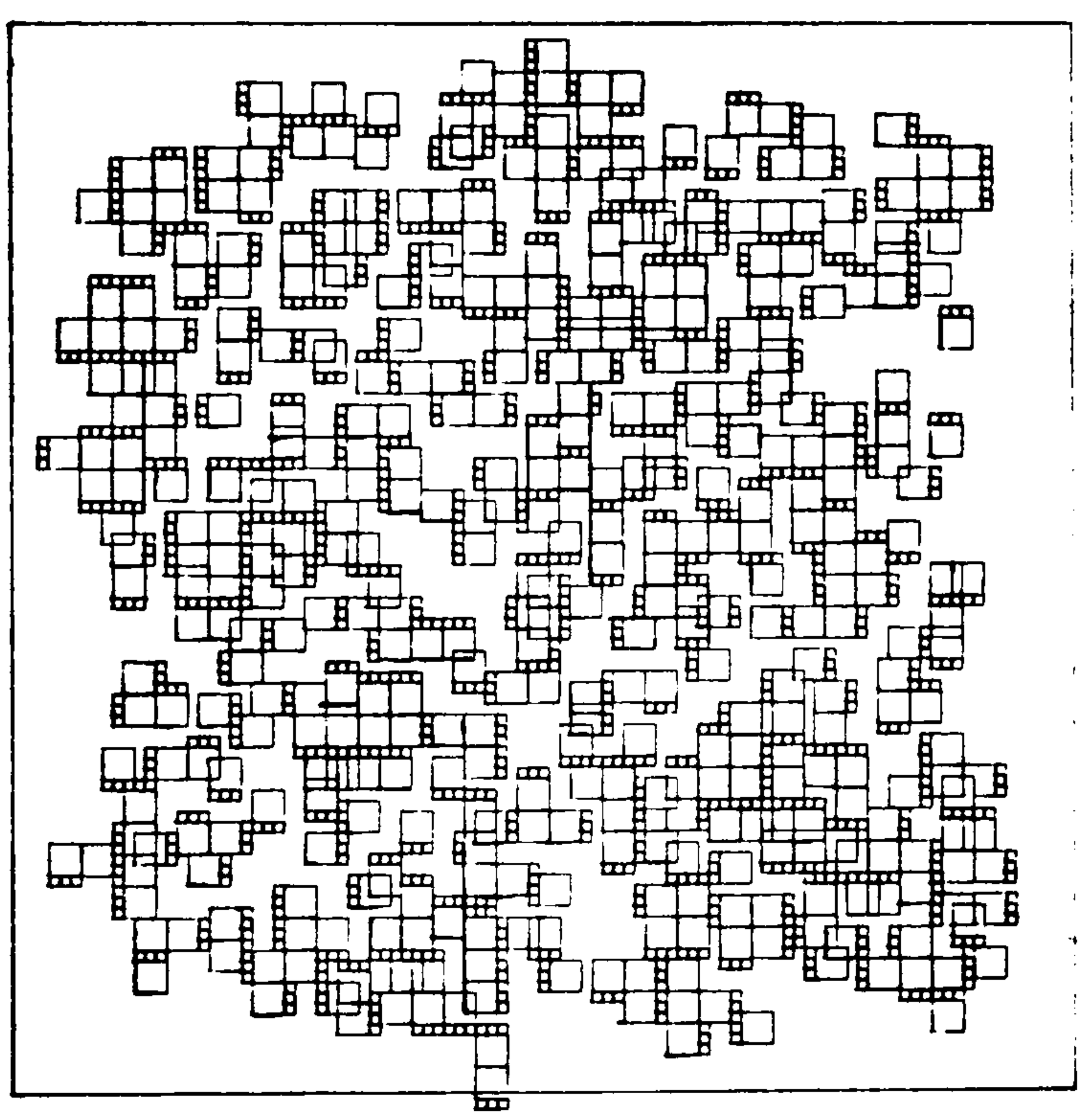


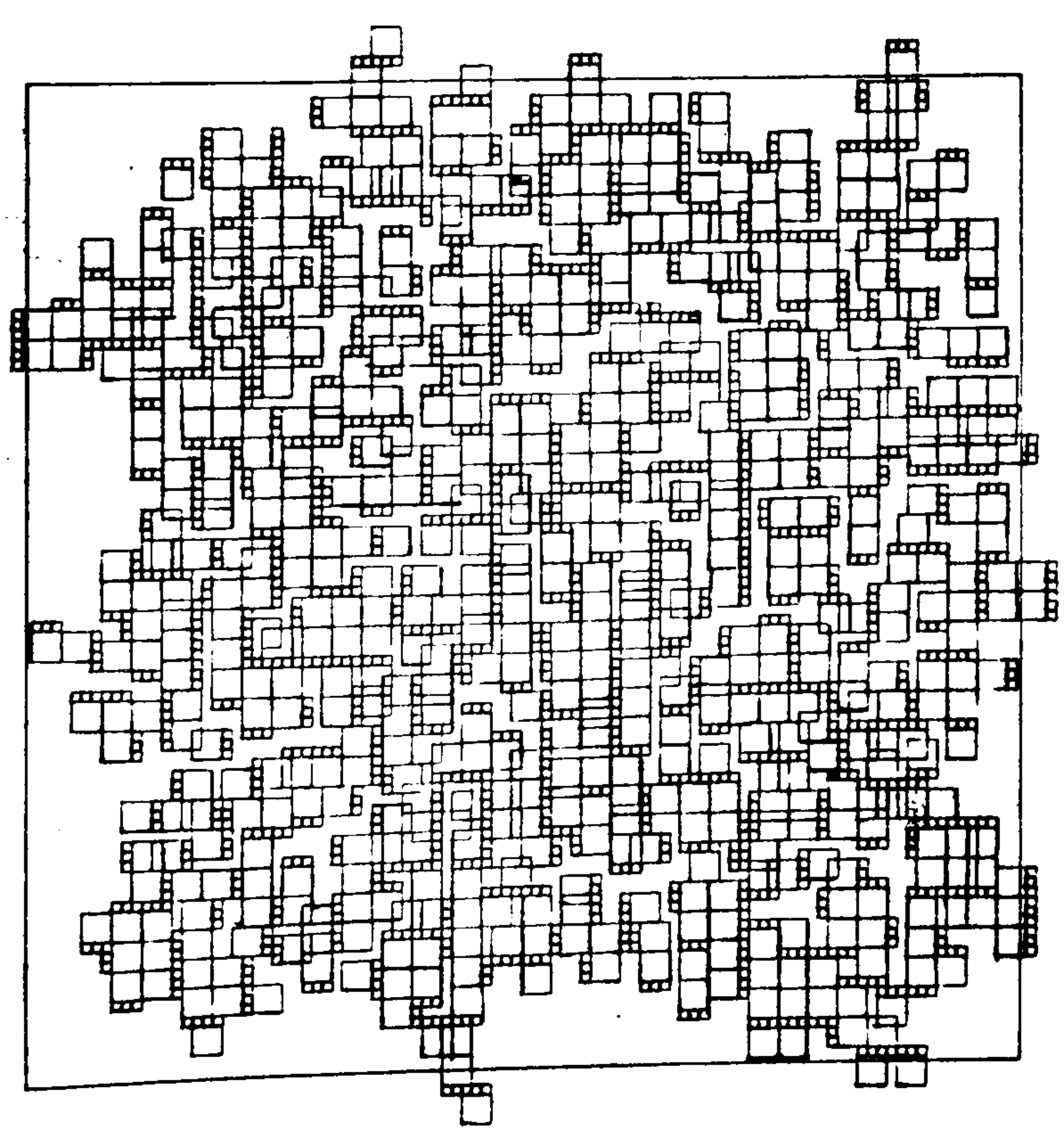
X clustering 0.40
Y clustering 0.00
Overlap allowed 5.00
Y sliding 0.80

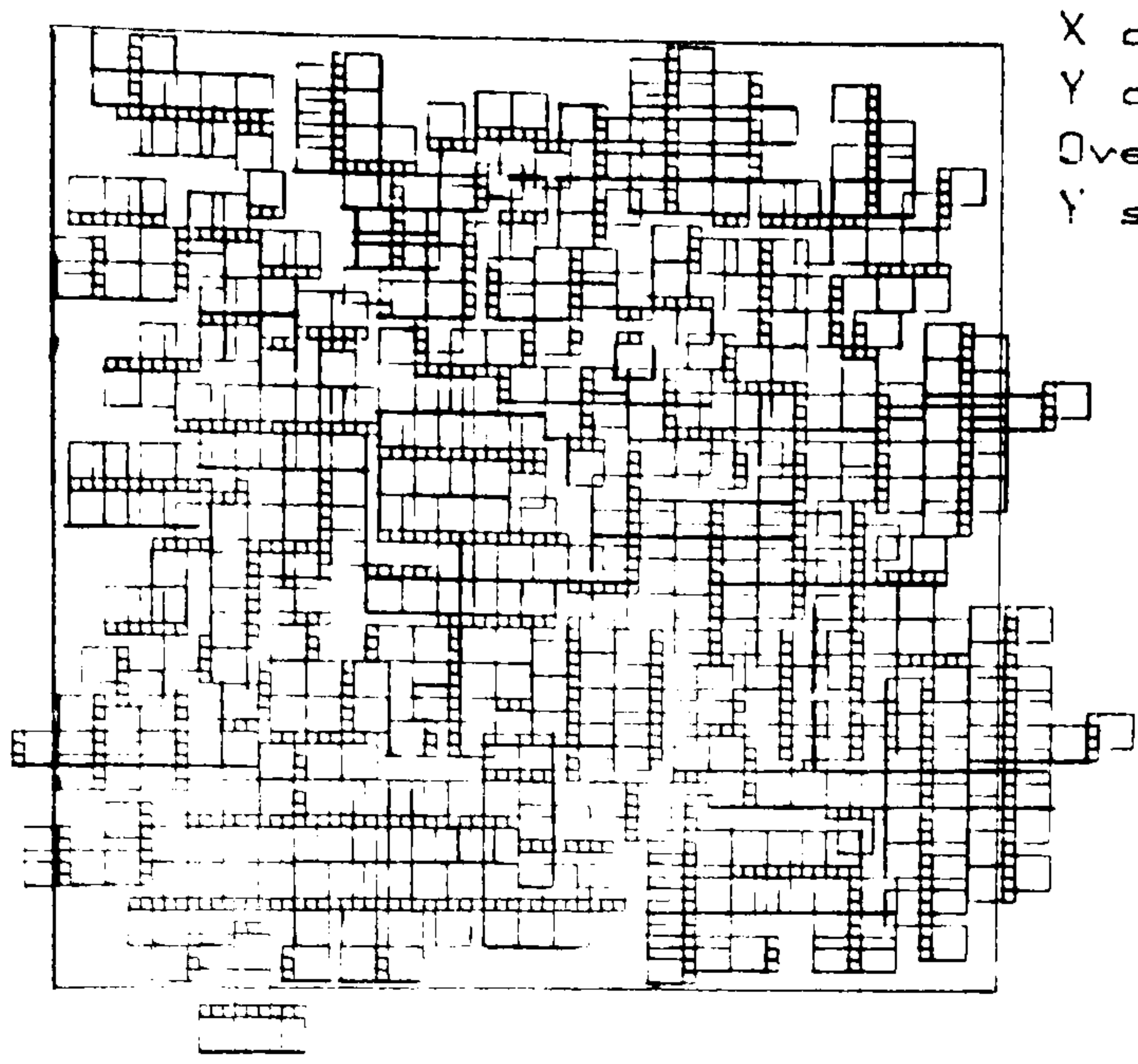



X clustering 0.40
Y clustering 0.20
Overlap allowed 5.00
Y sliding 0.80

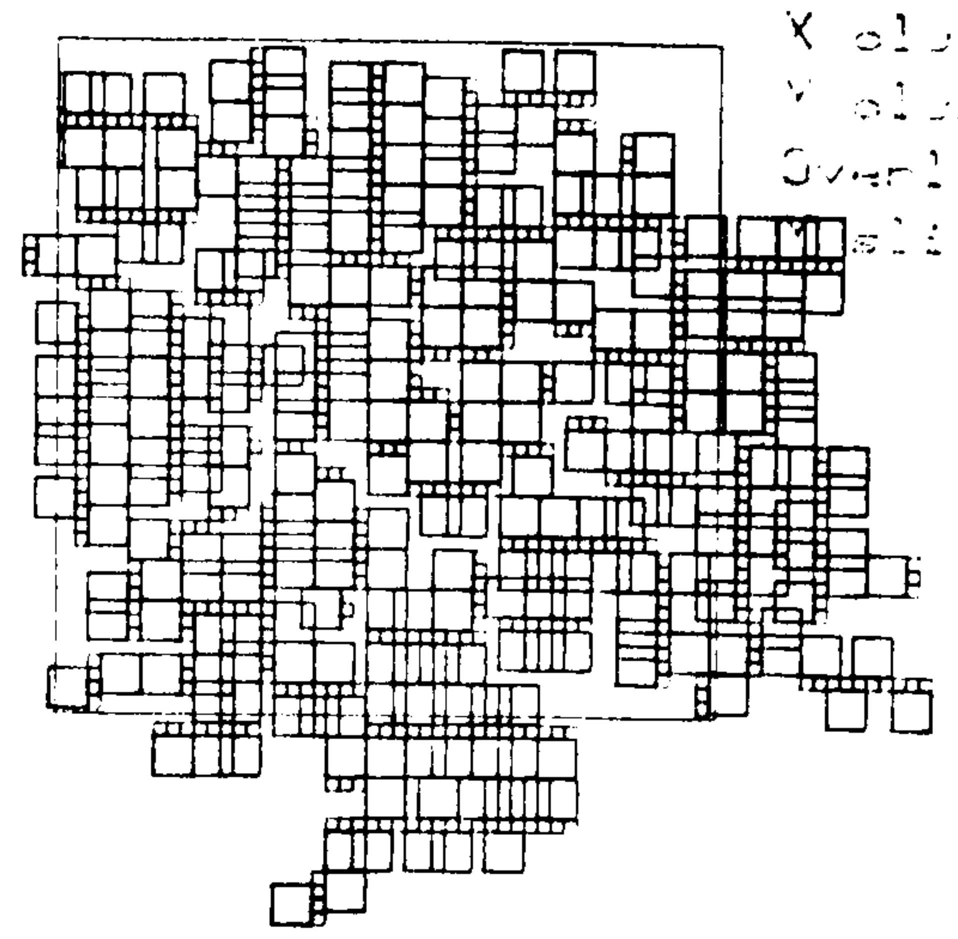

X clustering 0.40
Y clustering 0.20
Overlap allowed 5.00
Y sliding 0.80


X clustering 0.40
Y clustering 0.20
Overlap allowed 5.00
Y sliding 0.80

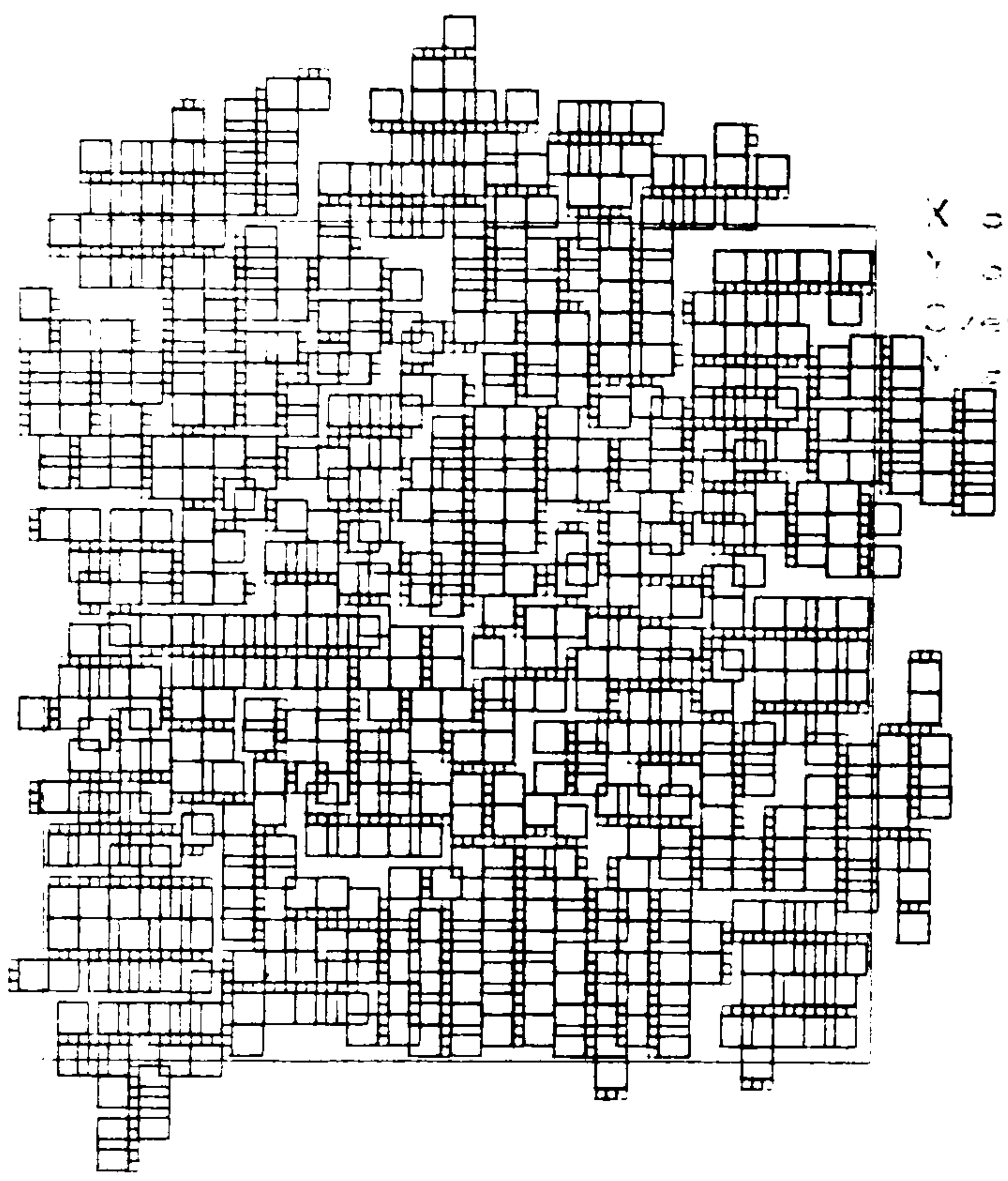

X clustering 0.40
Y clustering 0.20
Overlap allowed 5.00
Y sliding 0.80



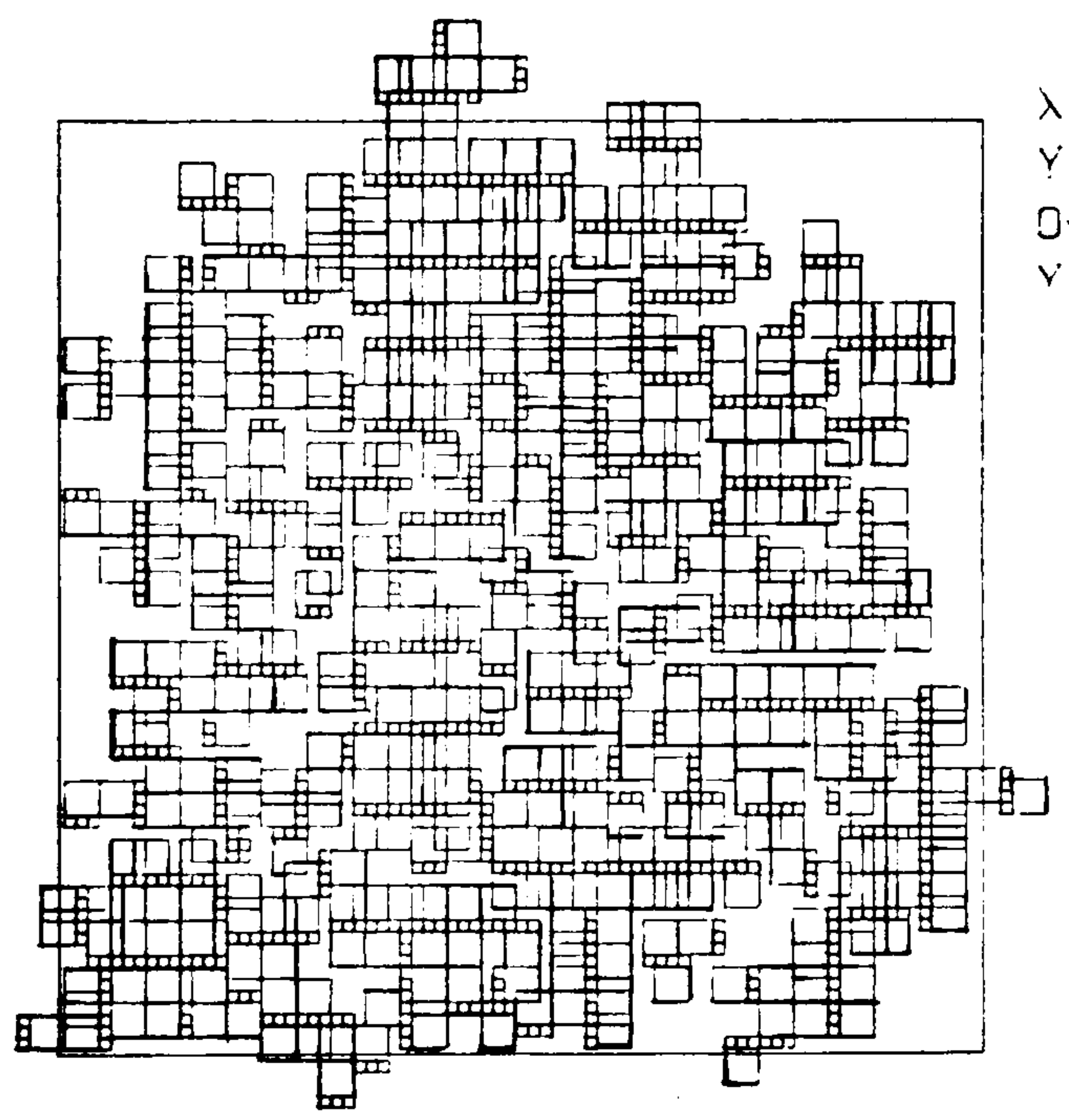
X clustering 0.40
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.80



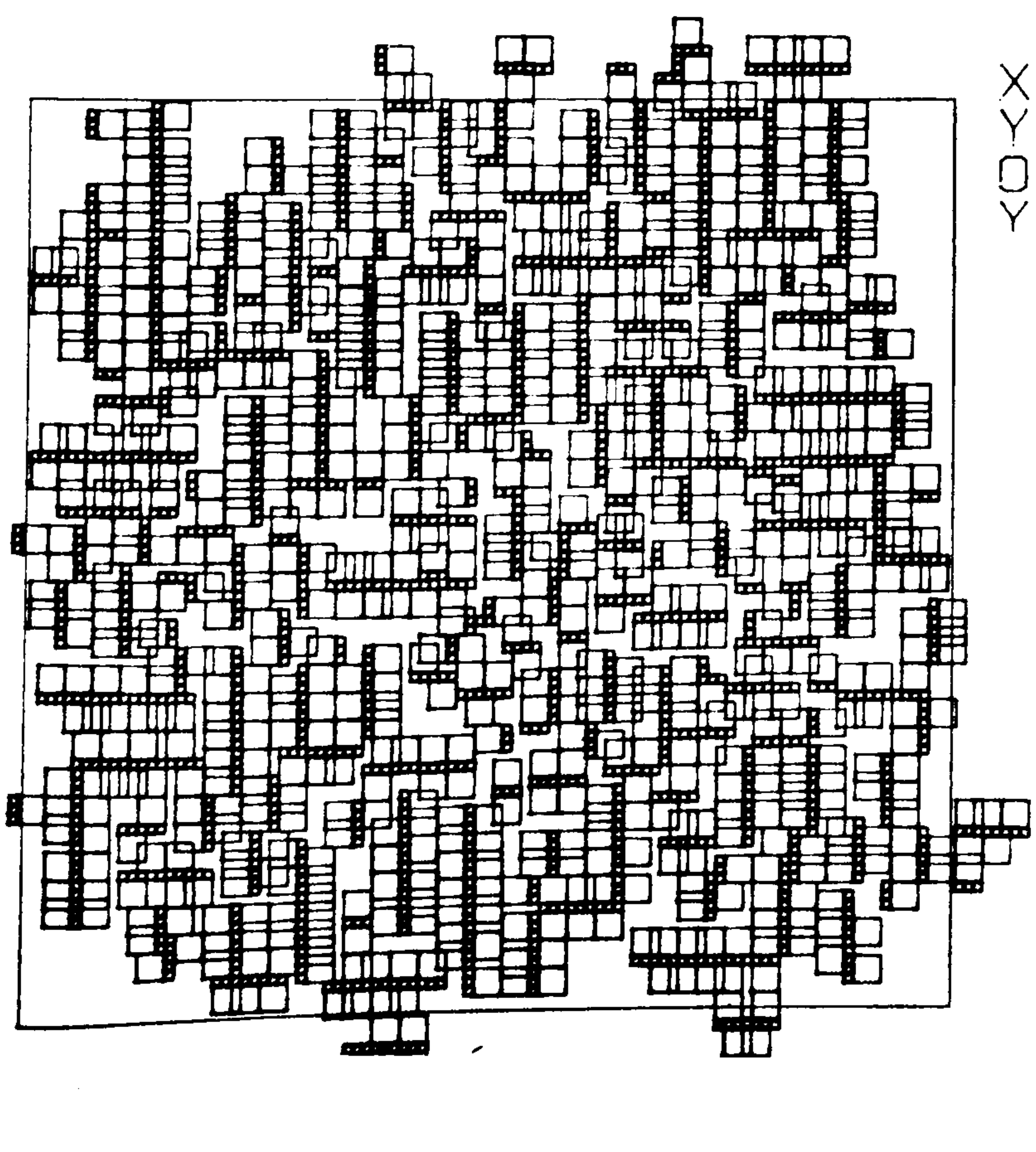
X clustering [illegible]
Y clustering [illegible]
Overlap allowed [illegible]
Y sliding [illegible]



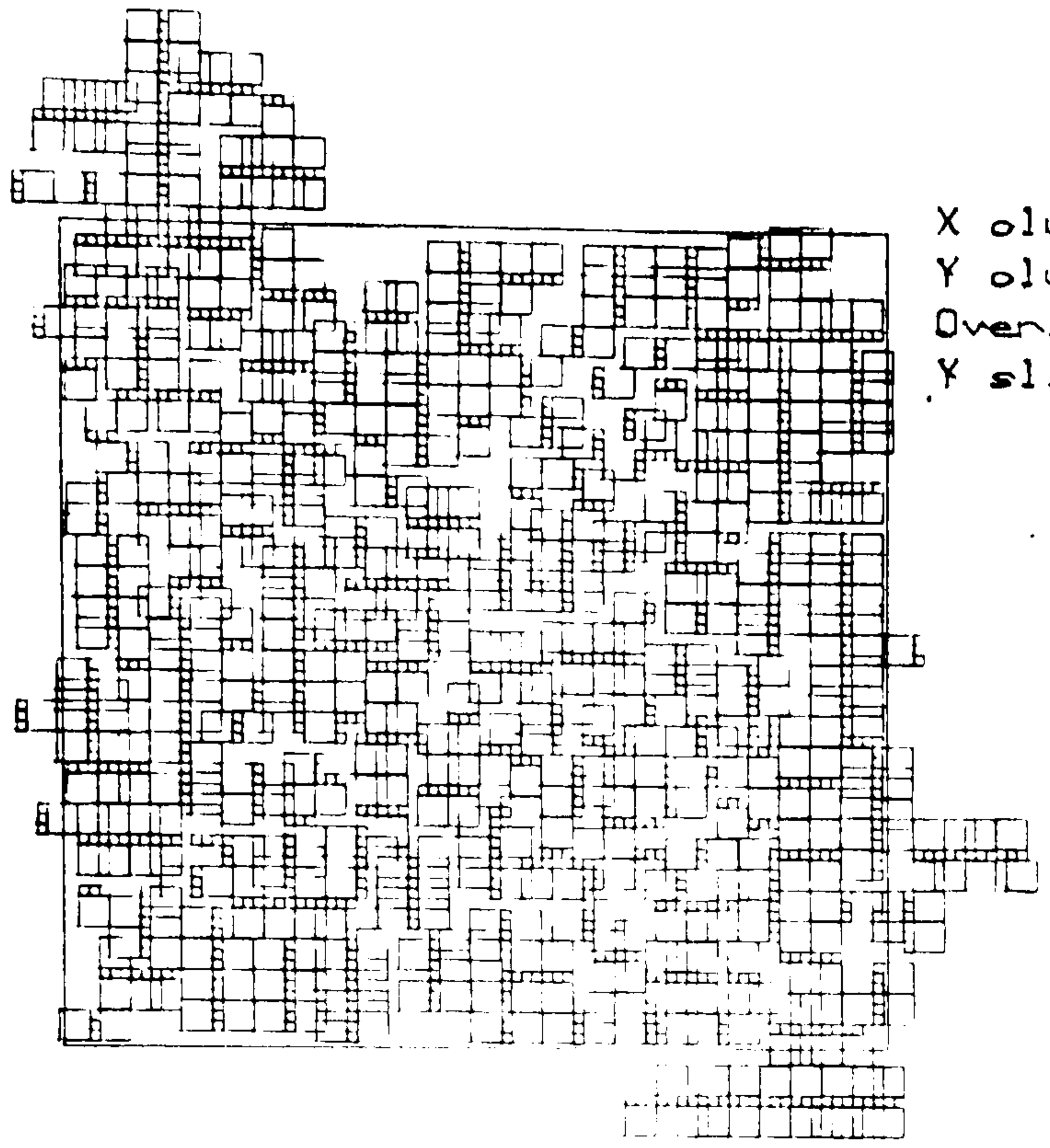
X clustering 0.40
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.80



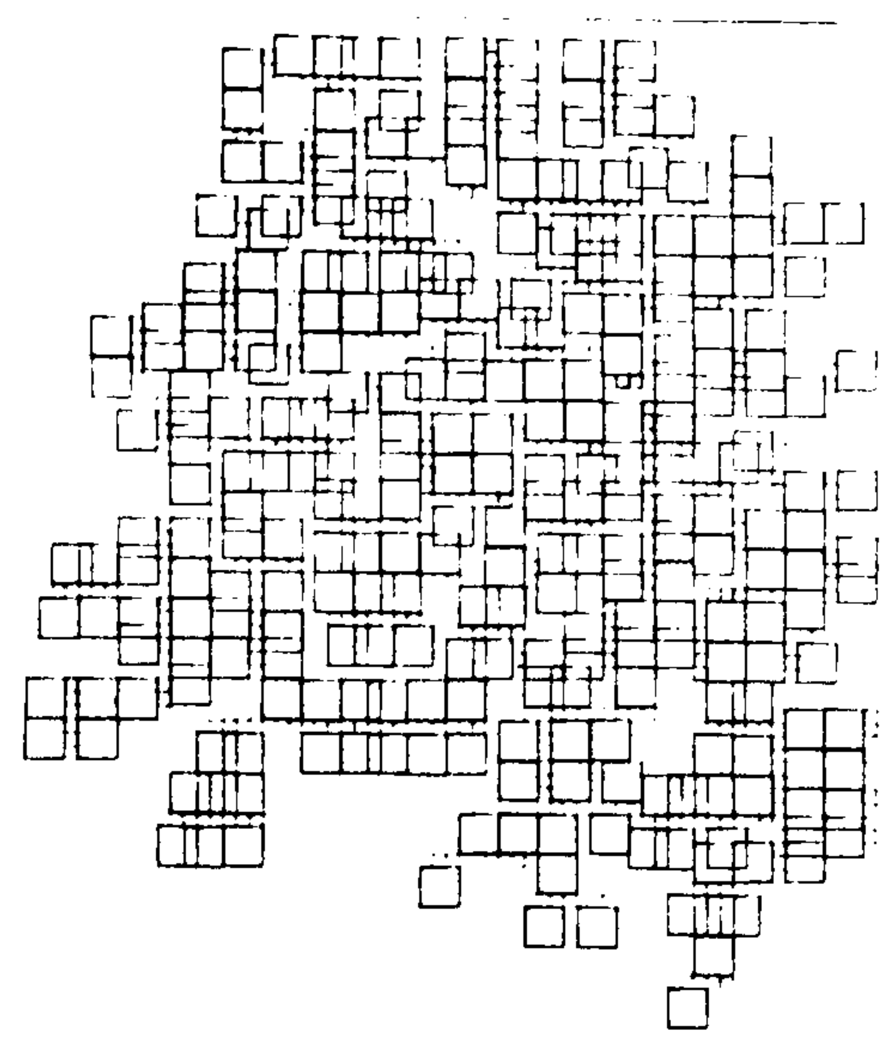
X clustering 0.40
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.80

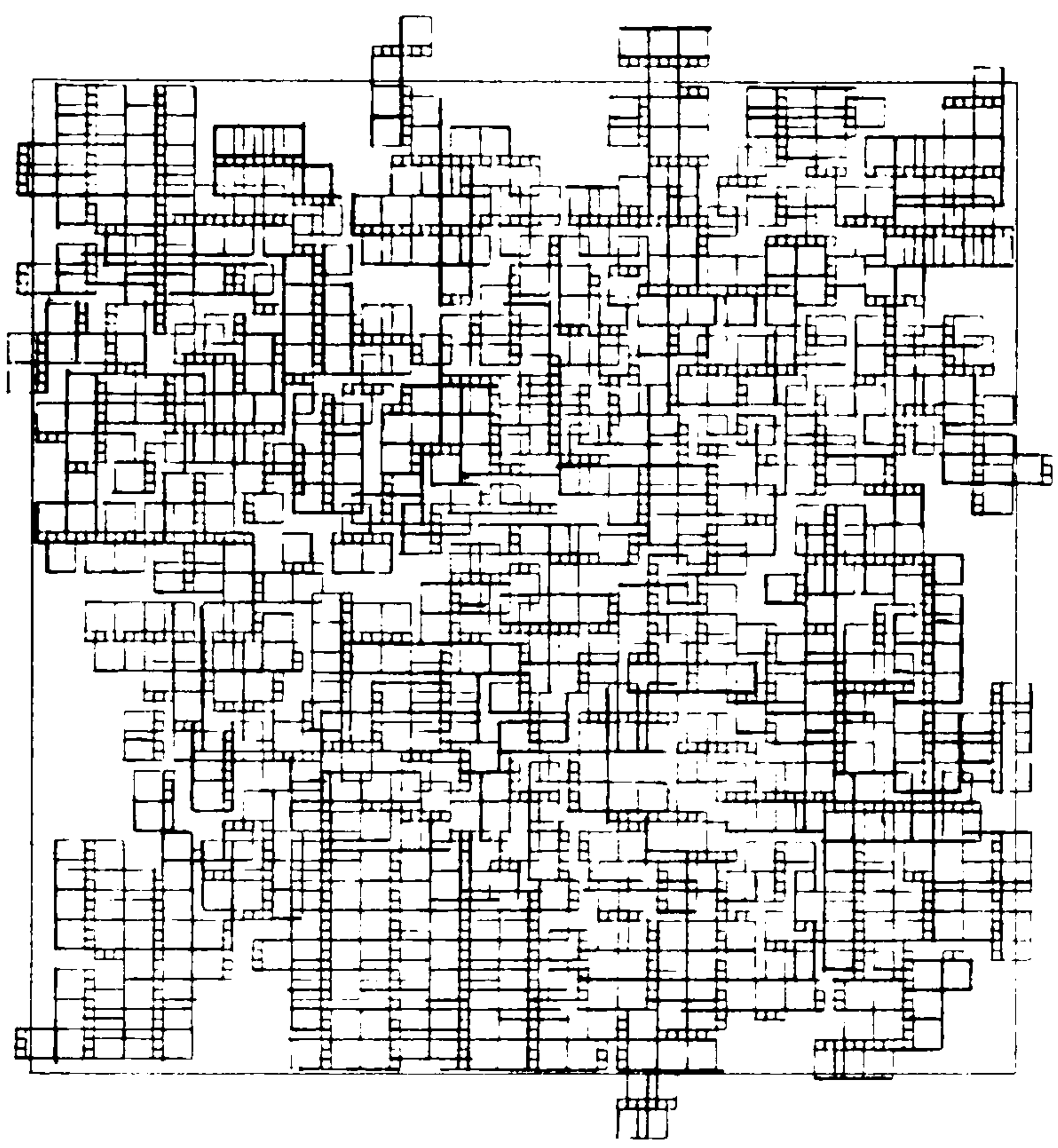


X clustering 0.40
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.80

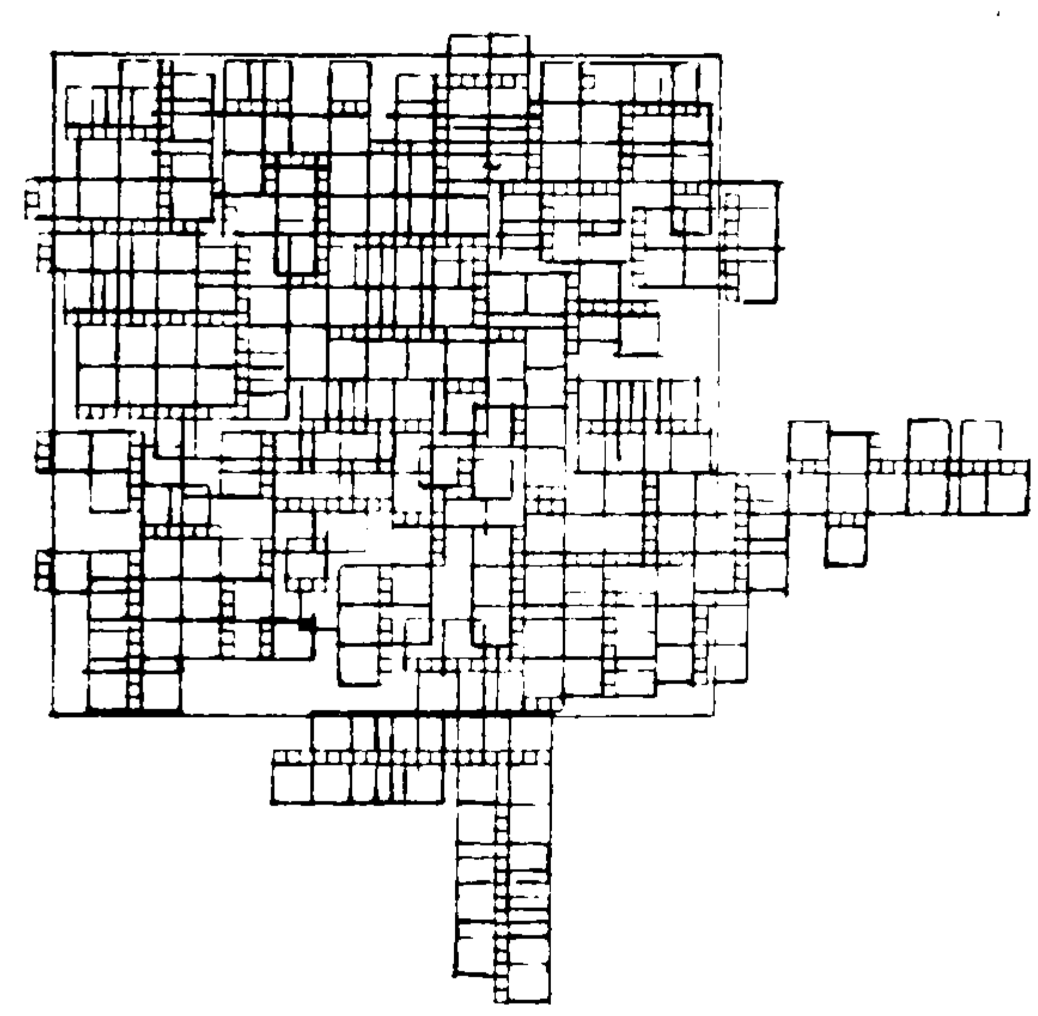


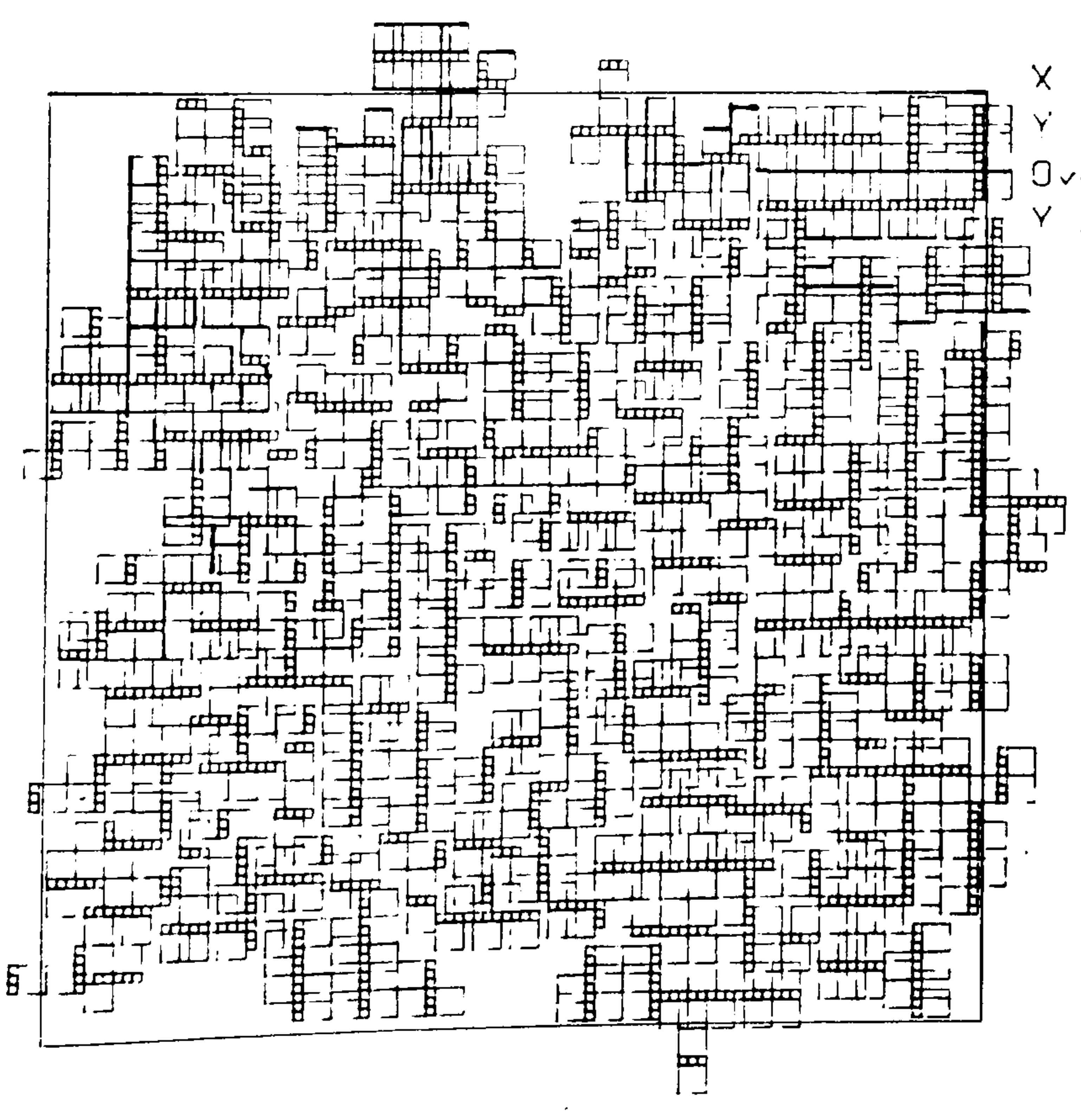
X clustering 0.40
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.40



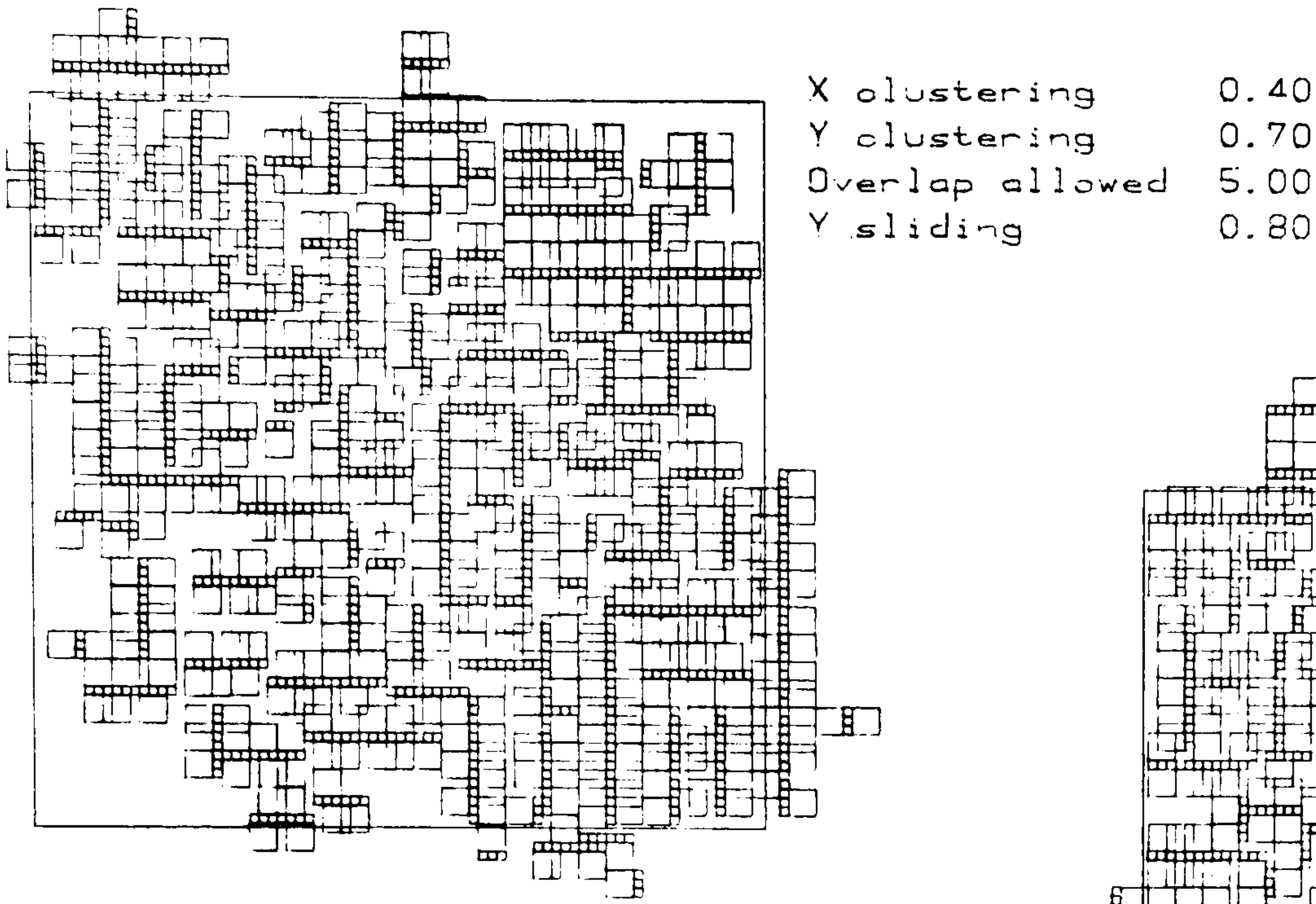


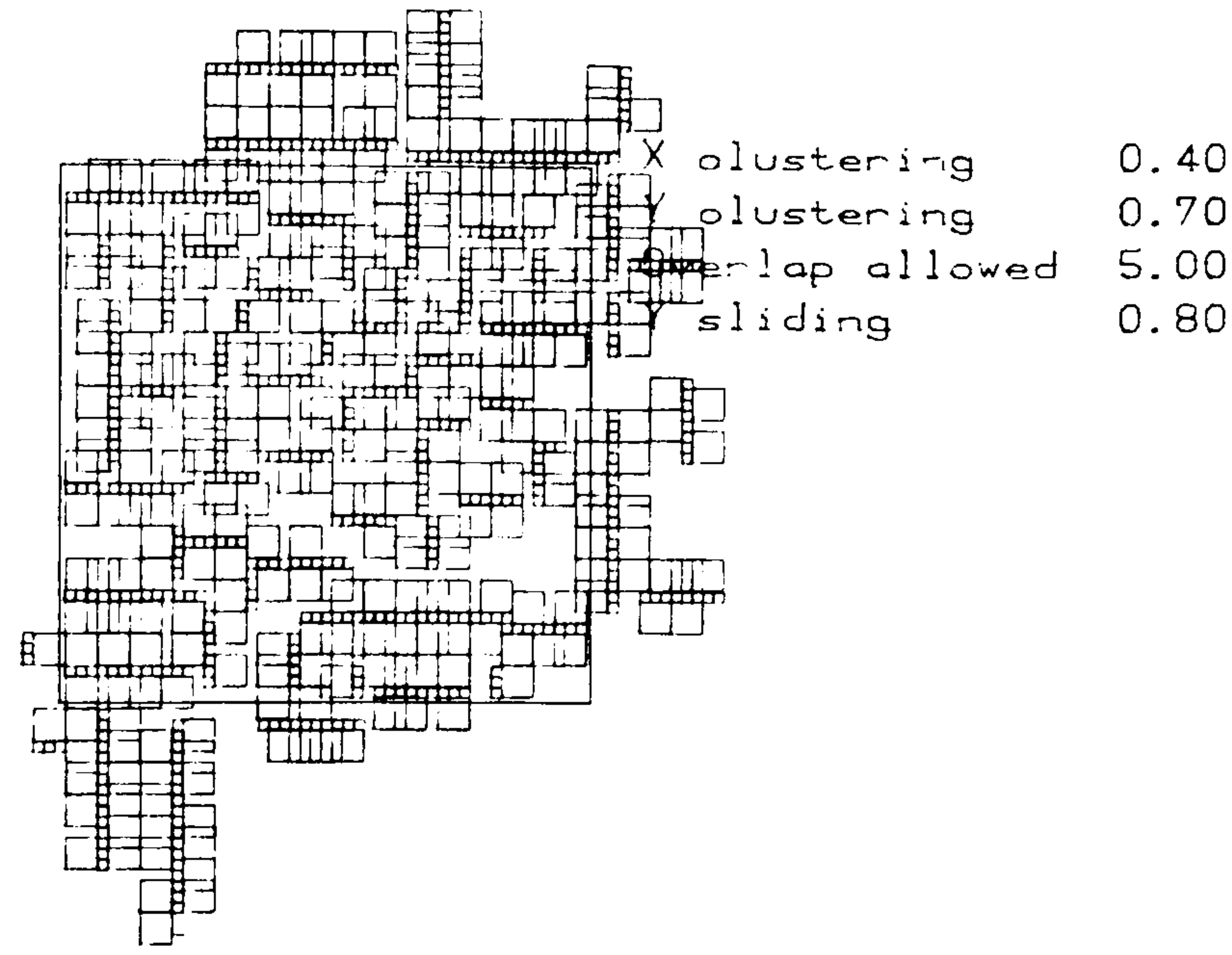
X clustering 0.40
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.80

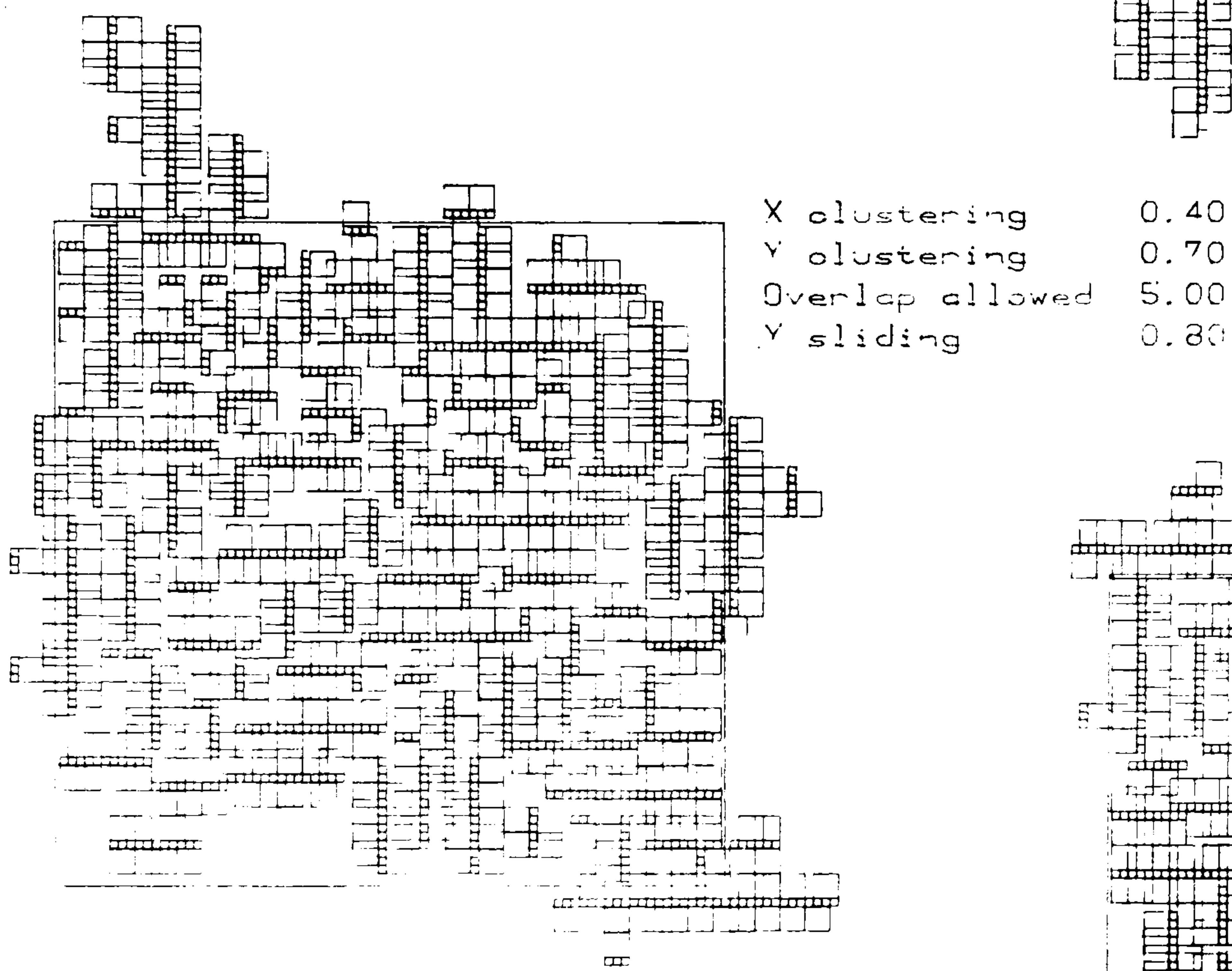


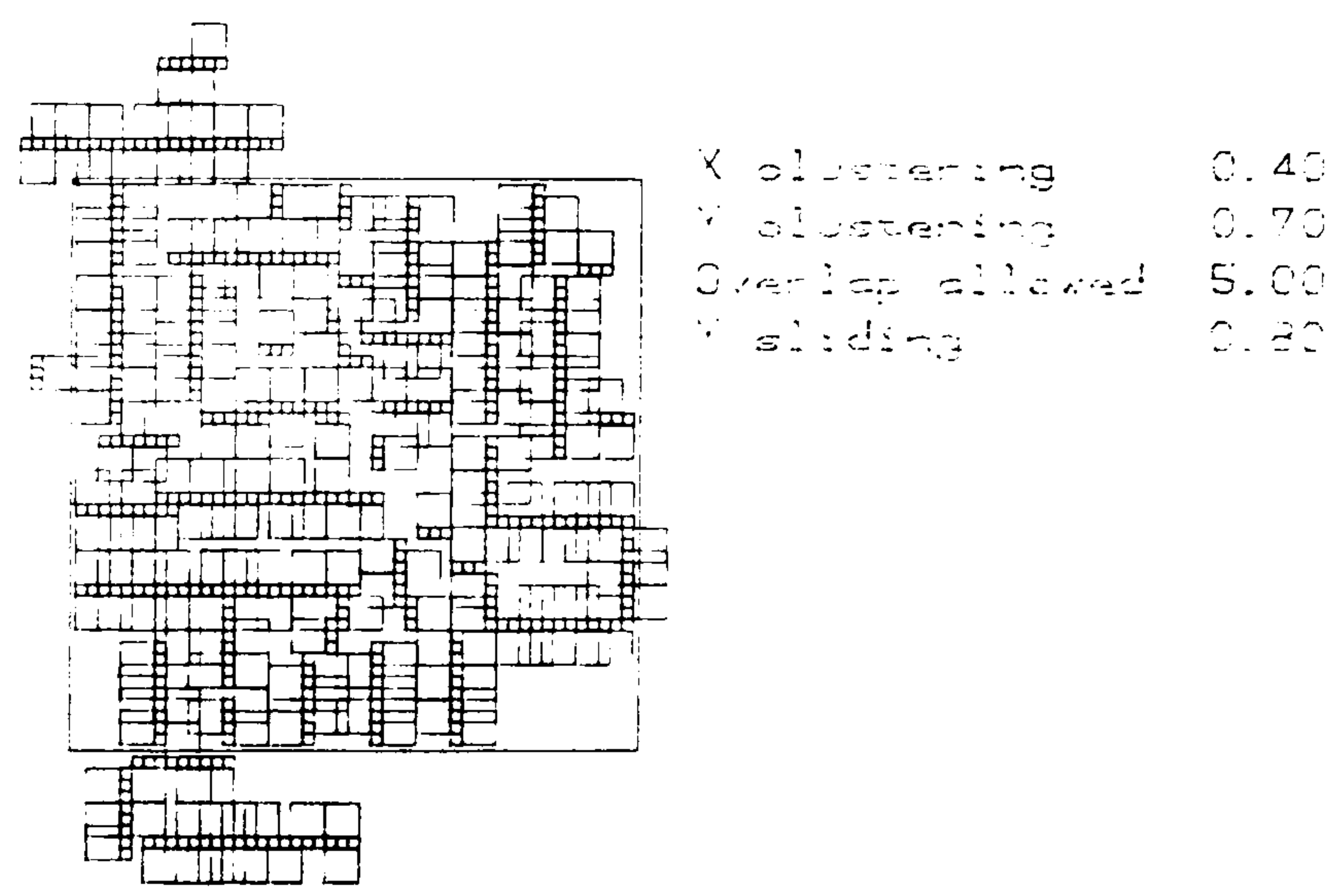


X clustering 0.40
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.80


X clustering 0.40
Y clustering 0.70
Overlap allowed 5.00
Y sliding 0.80


X clustering 0.40
Y clustering 0.70
Overlap allowed 5.00
Y sliding 0.80


X clustering 0.40
Y clustering 0.70
Overlap allowed 5.00
Y sliding 0.80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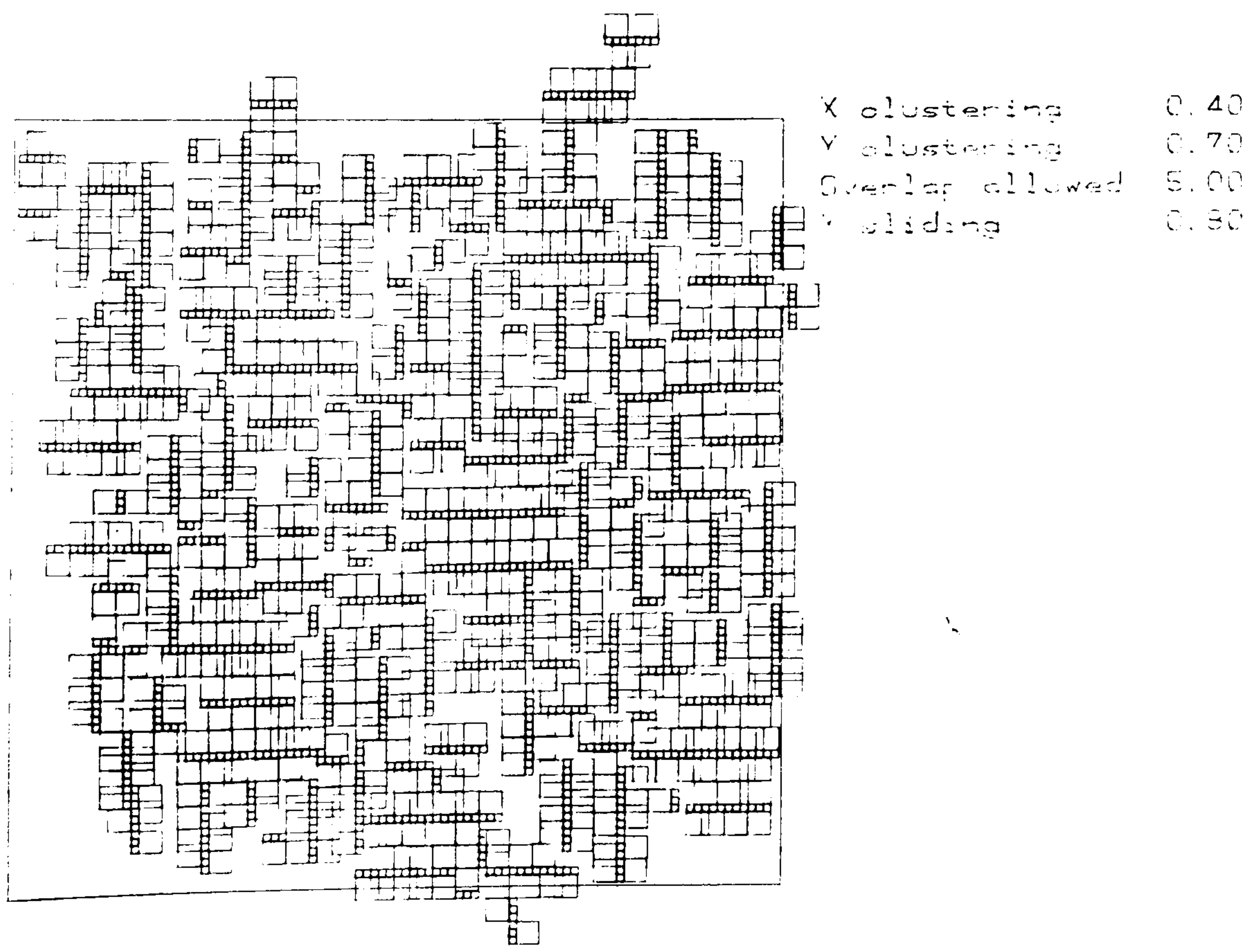
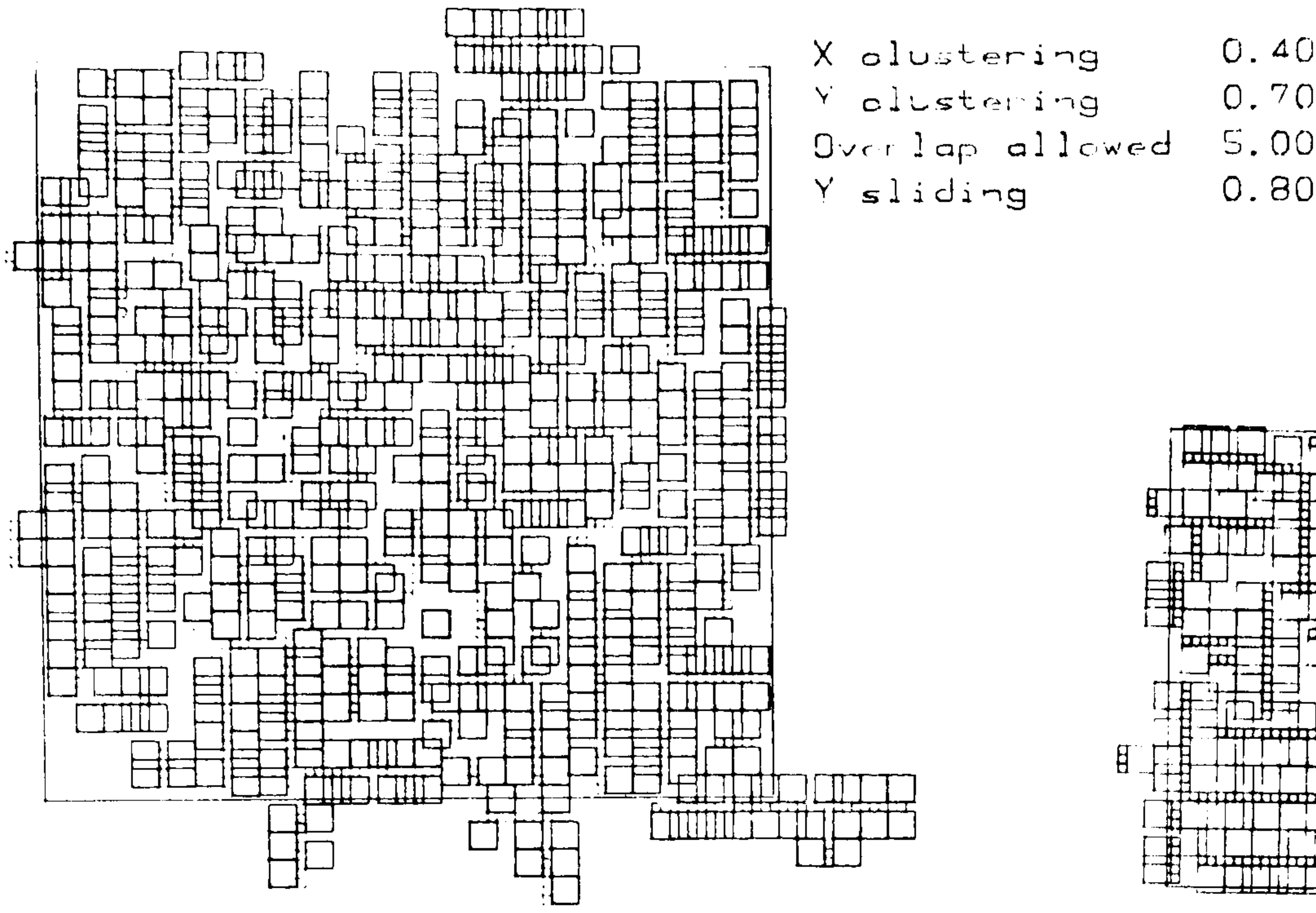
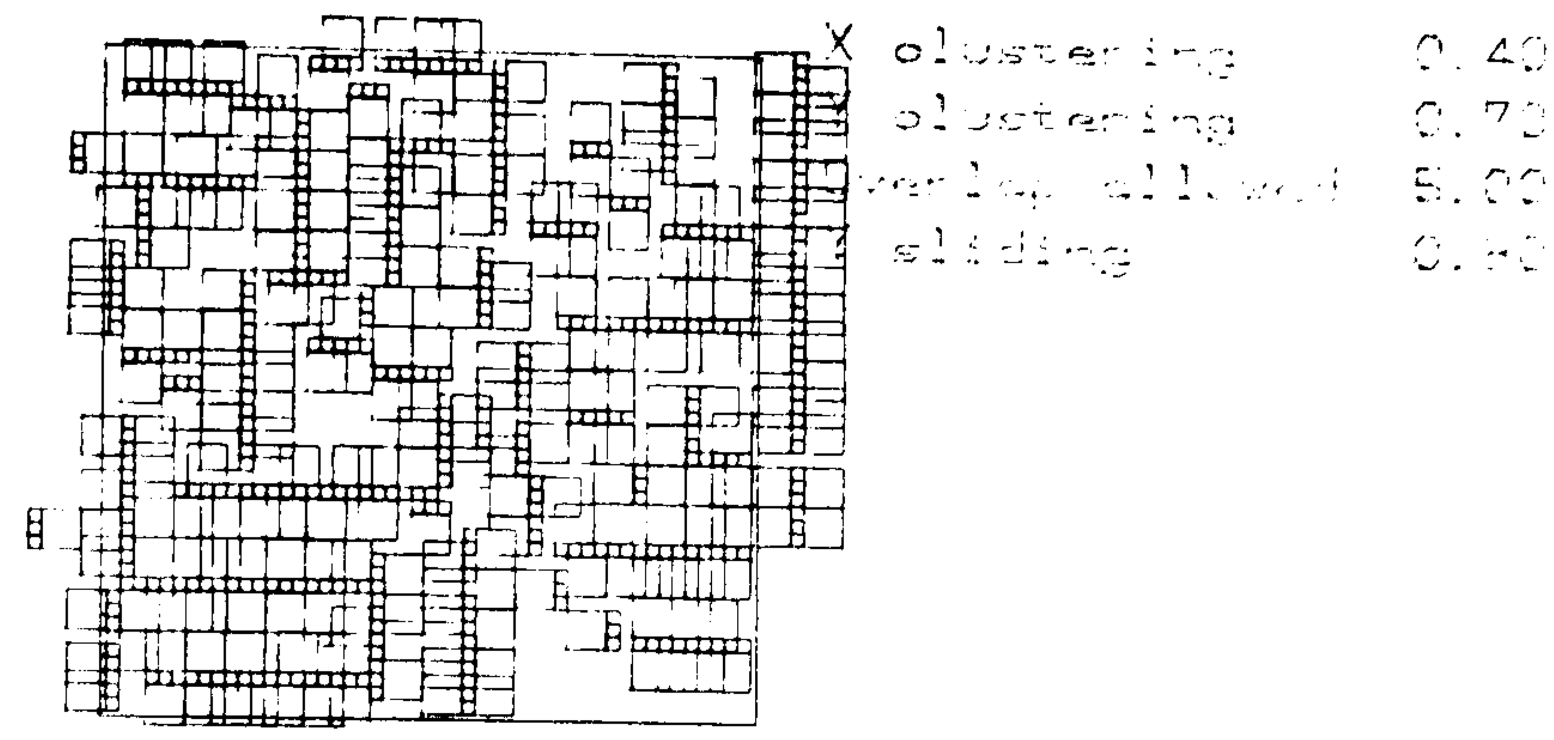
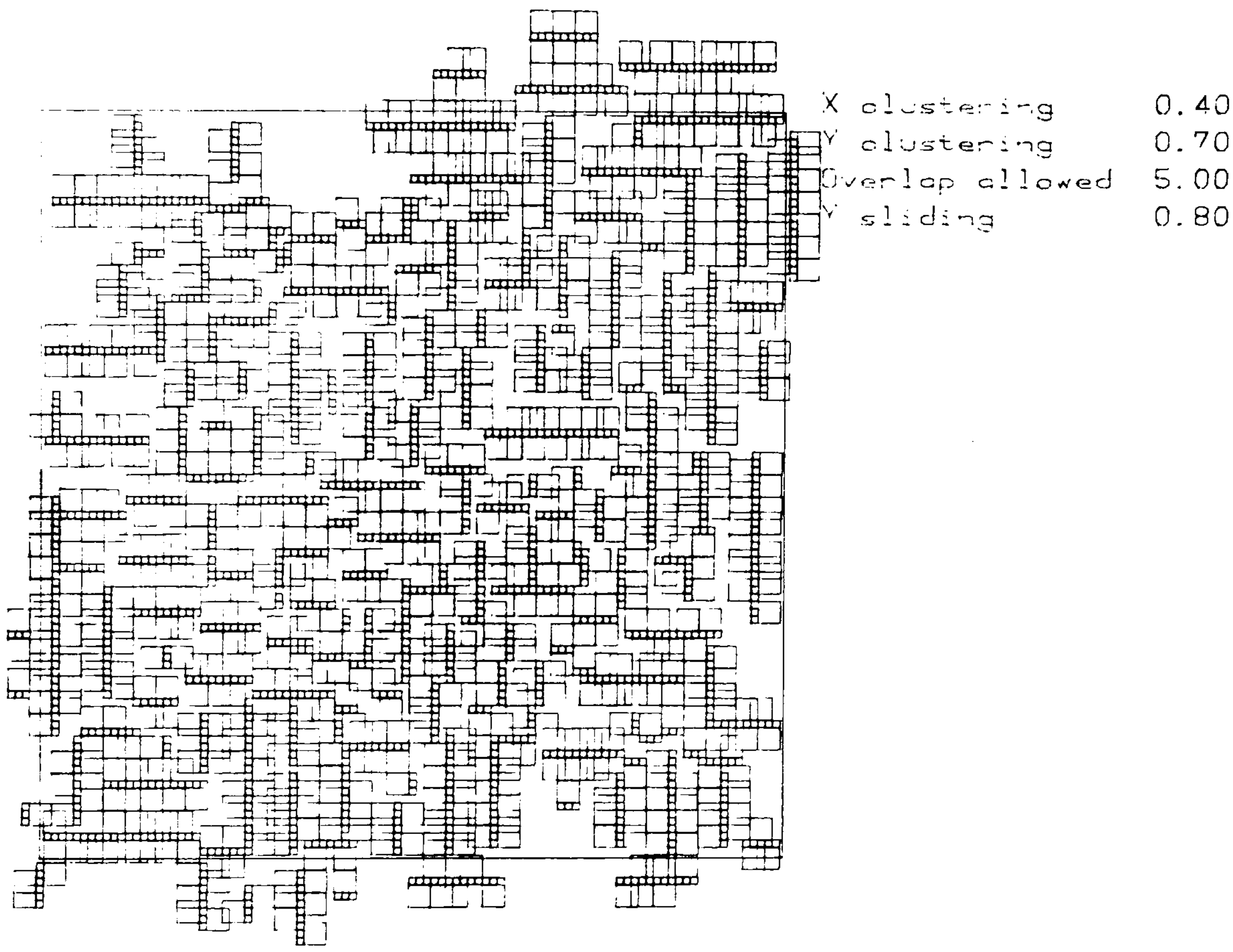
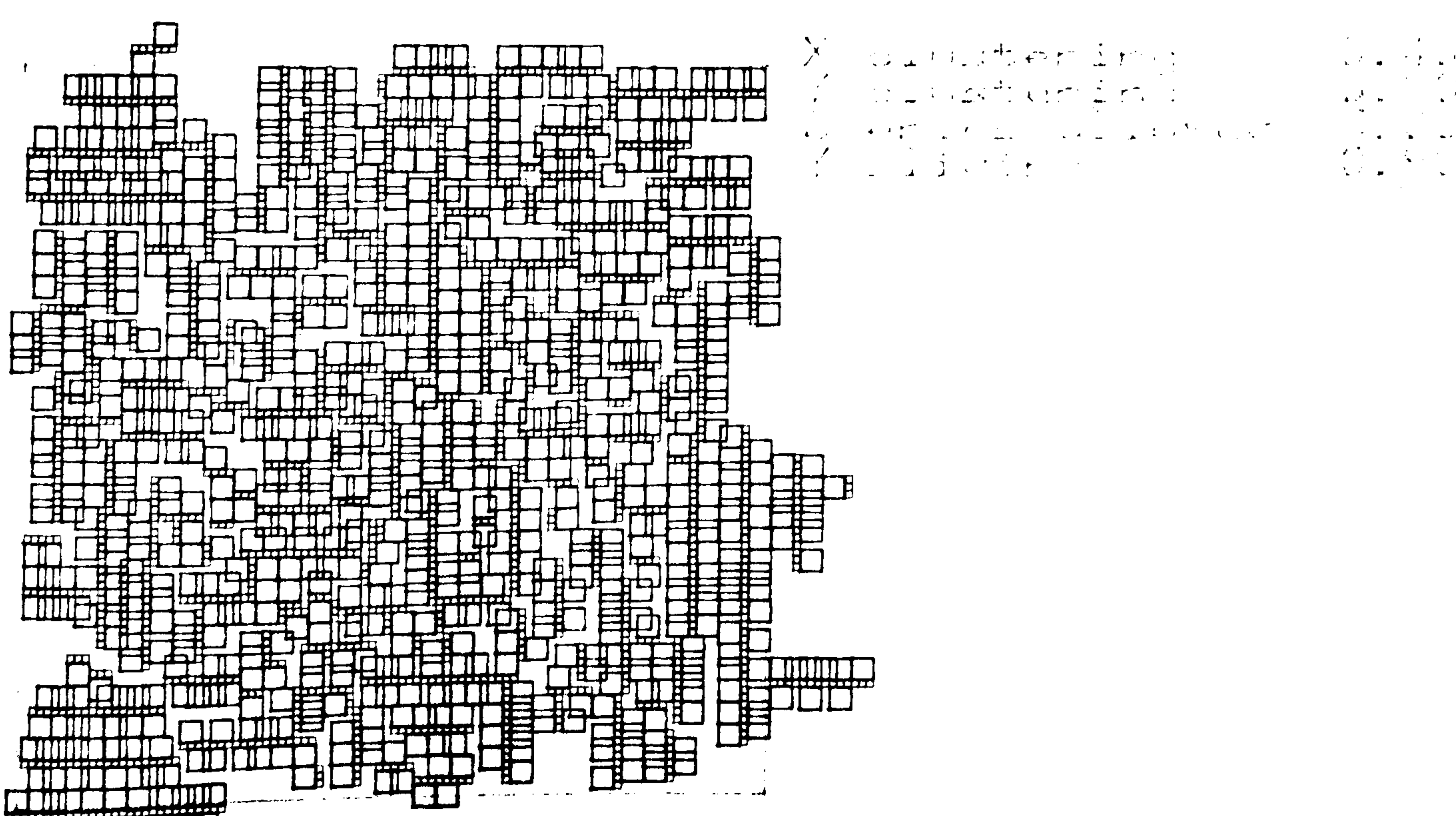
Y clustering 0.70
Overlap allowed 5.00
Y sliding 0.80

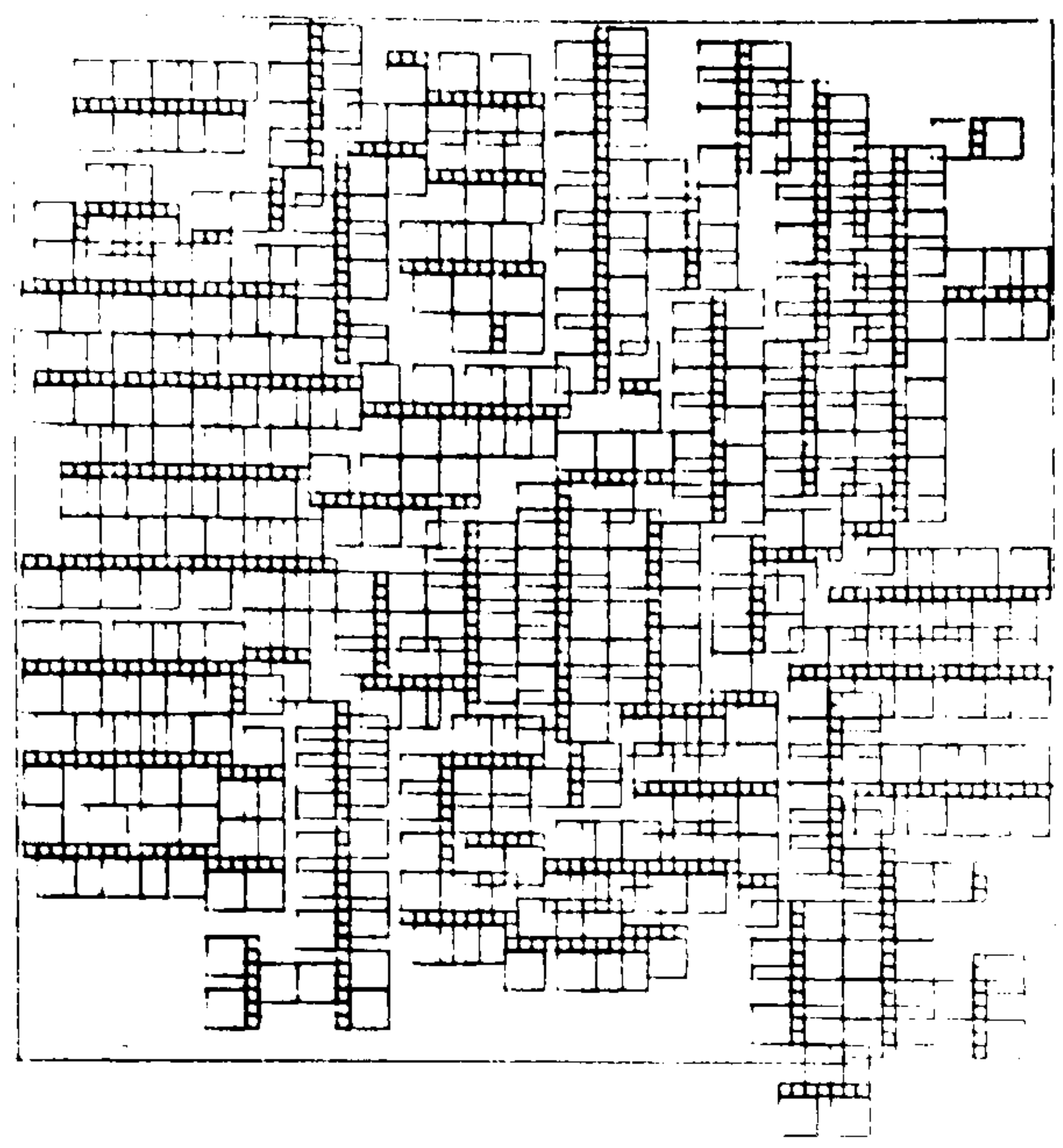

X clustering 0.40
Y clustering 0.70
Overlap allowed 5.00
Y sliding 0.80

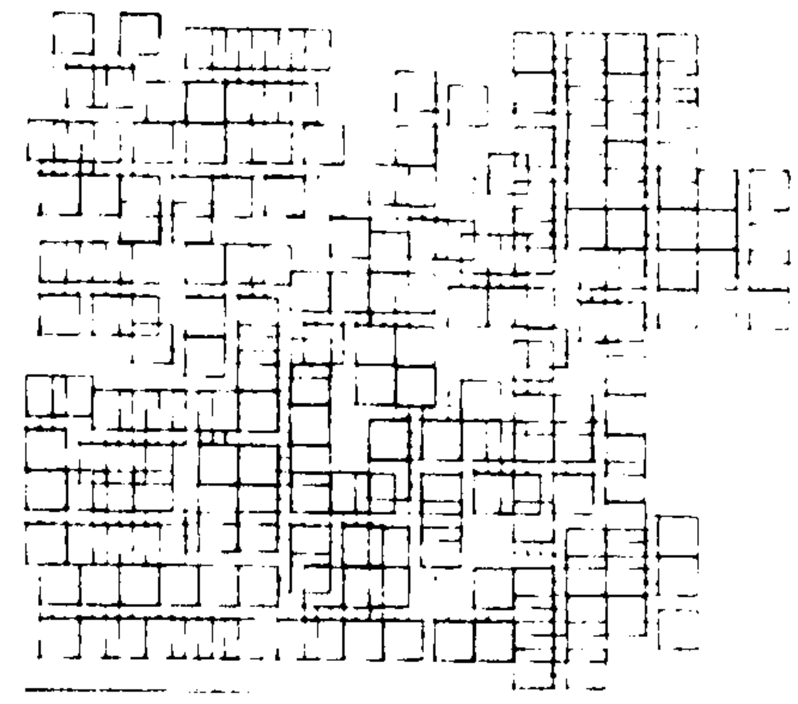

X clustering 0.40
Y clustering 0.70
Overlap allowed 5.00
Y sliding 0.80

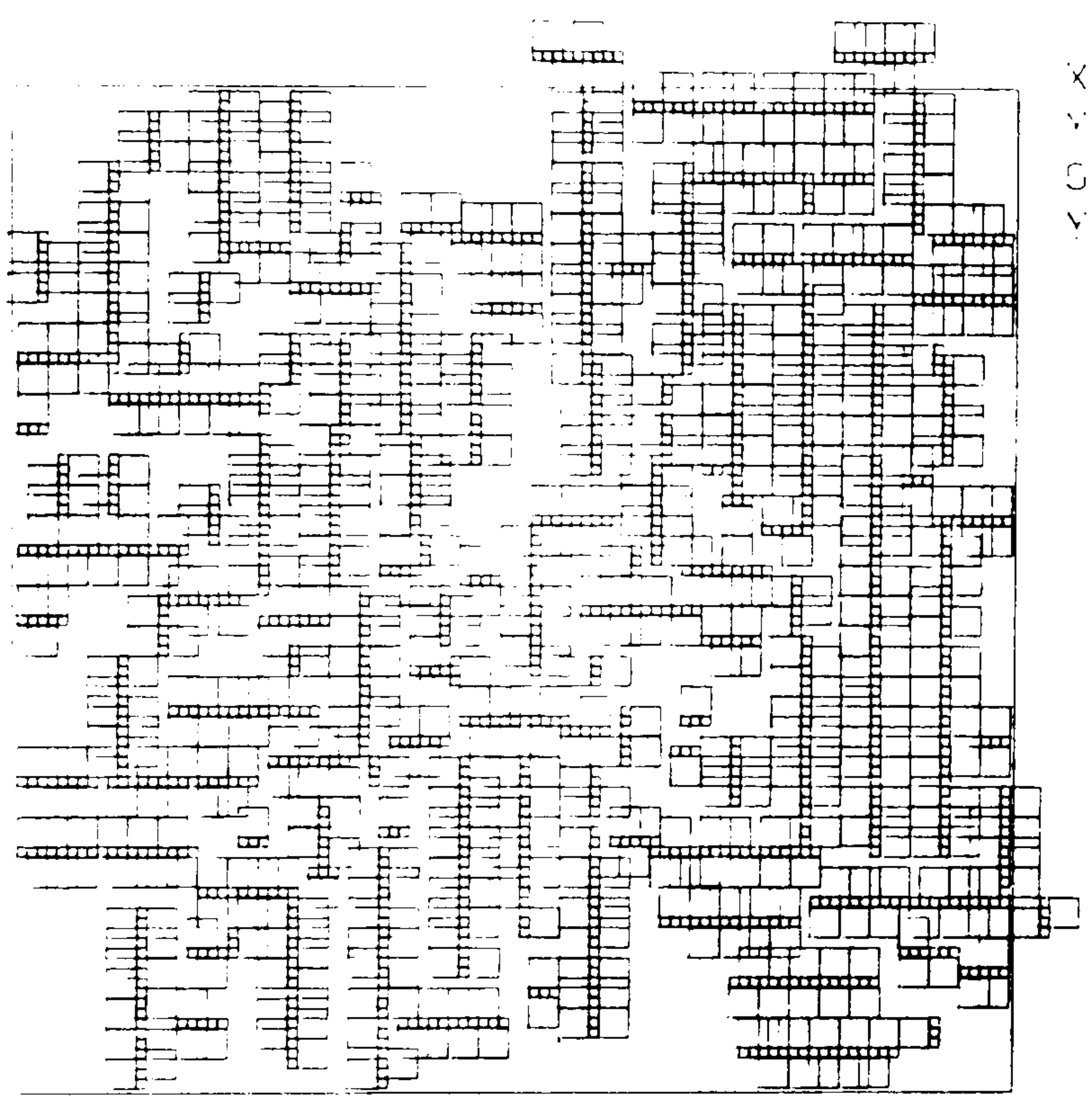

X clustering 0.40
clustering 0.70
verlap allowed 5.00
sliding


X clustering 0.40
Y clustering 0.70
Overlap allowed 5.00
Y sliding 0.80

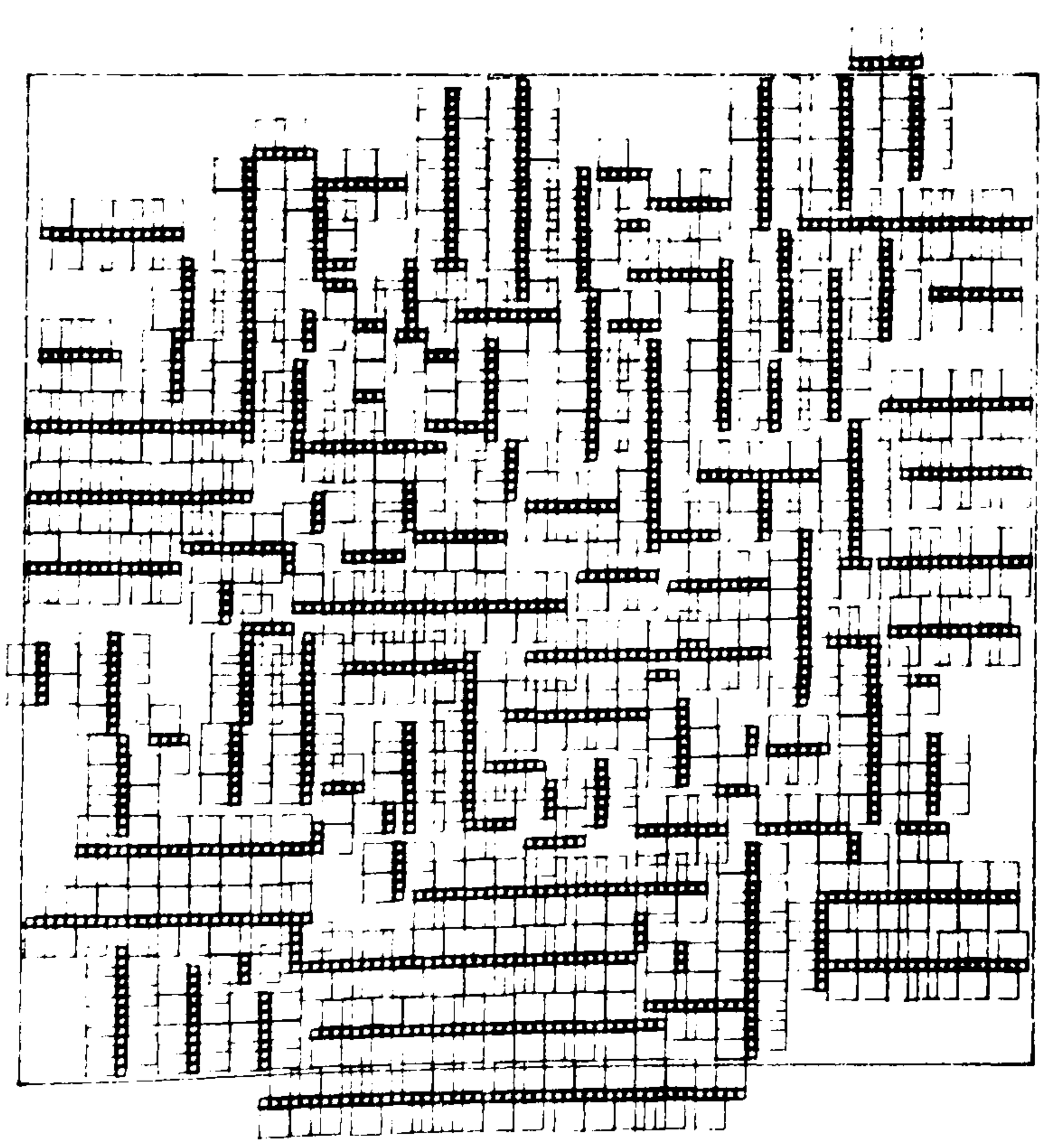




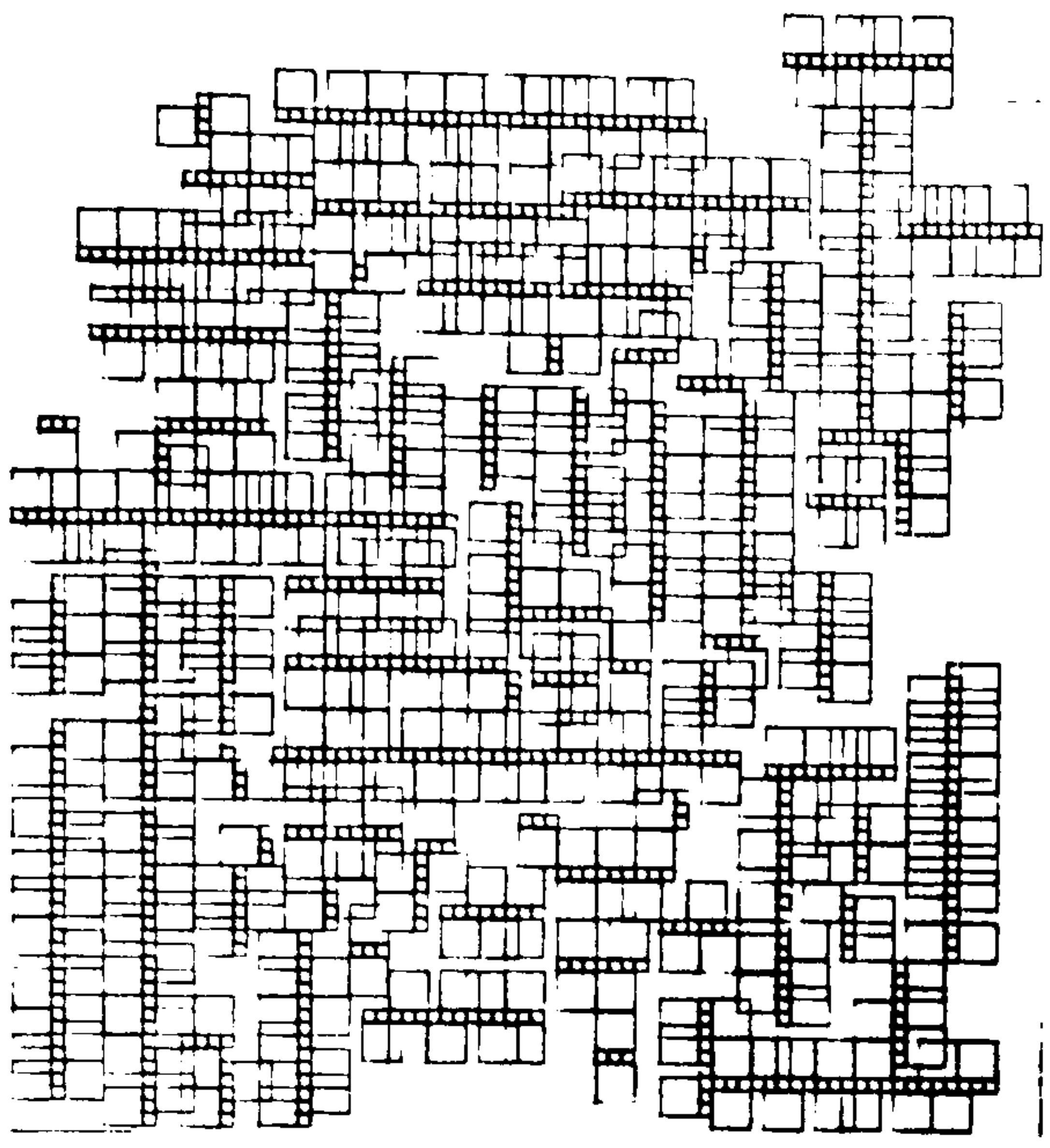


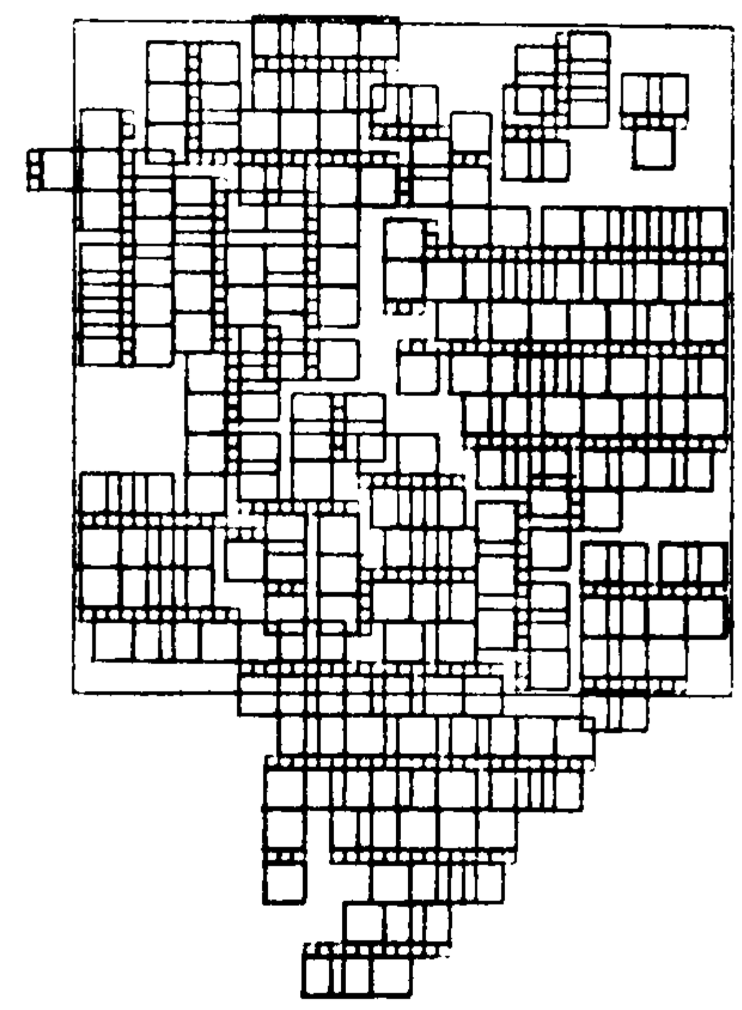


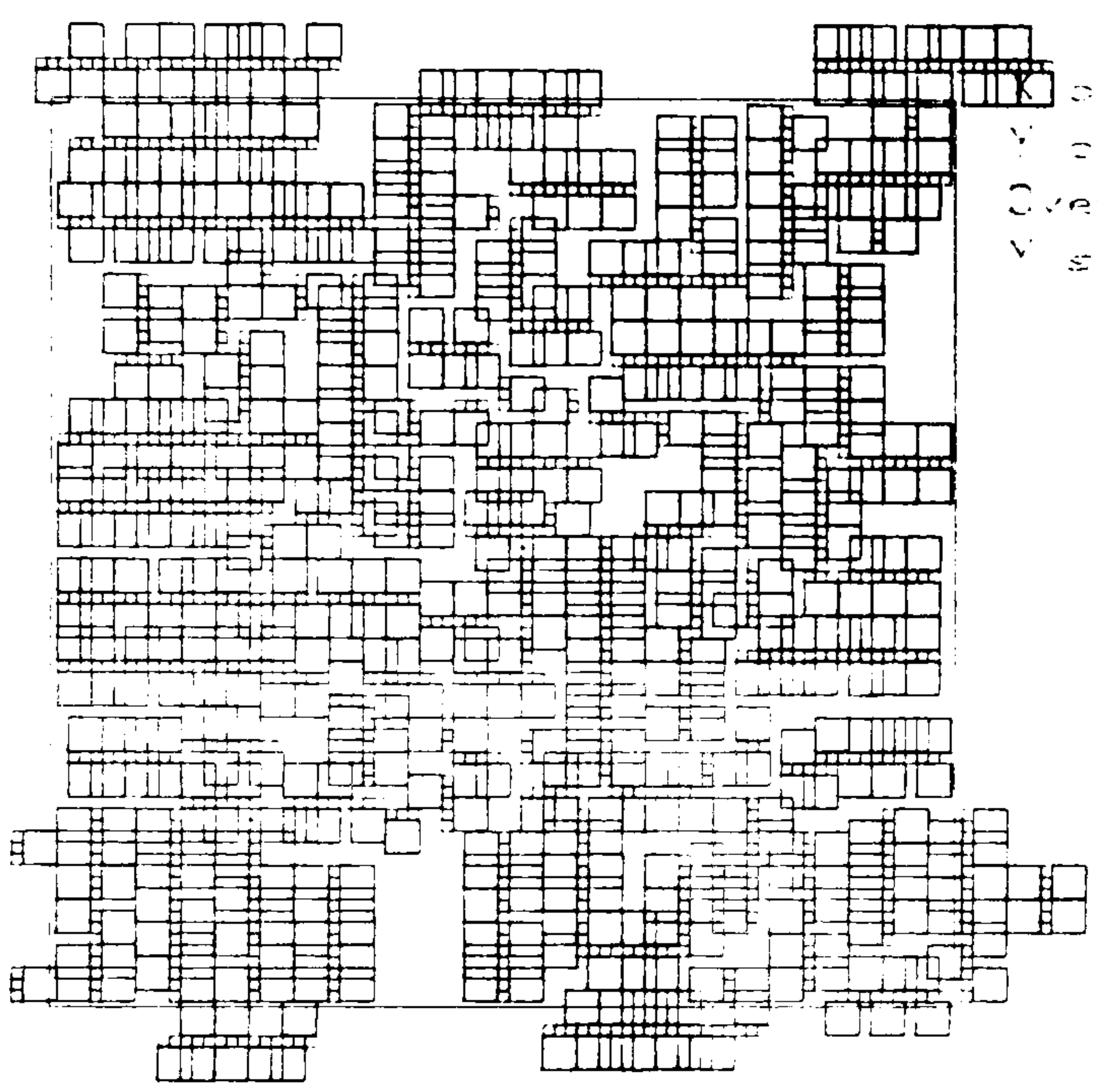
X clustering 0.40
Y clustering 0.80
Overlap allowed 5.00
Y sliding 0.80



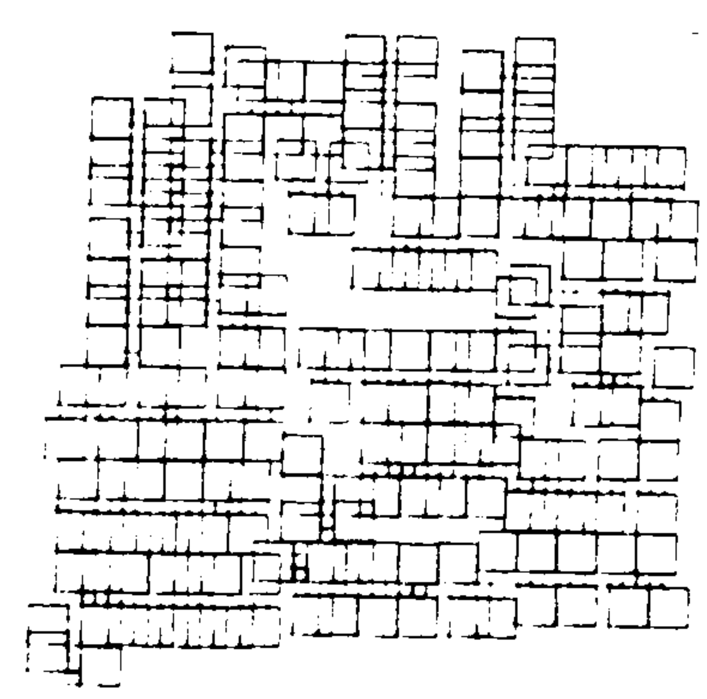
X clustering 0.40
Y clustering 0.80
Overlap allowed 5.00
Y sliding 0.80

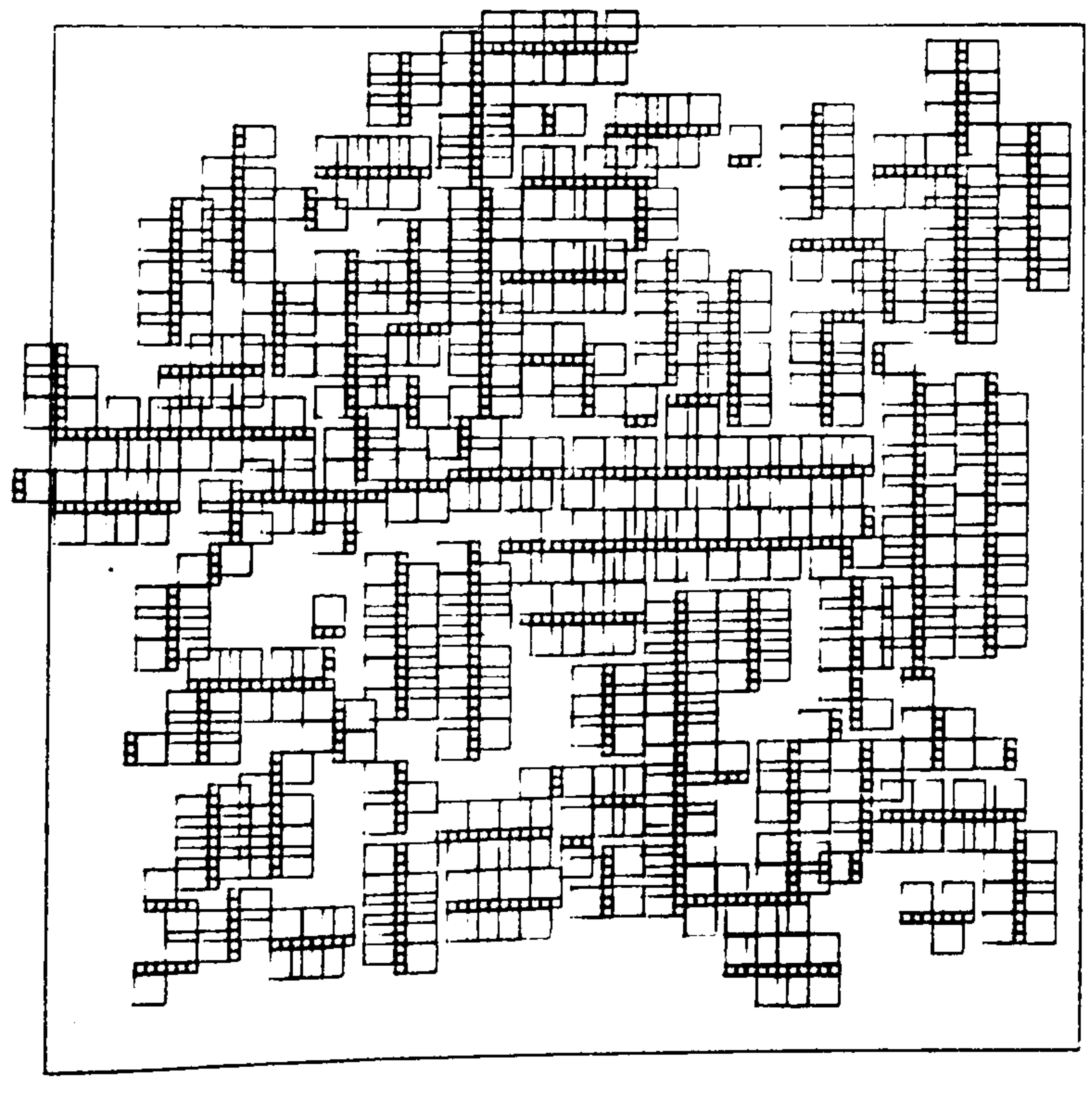




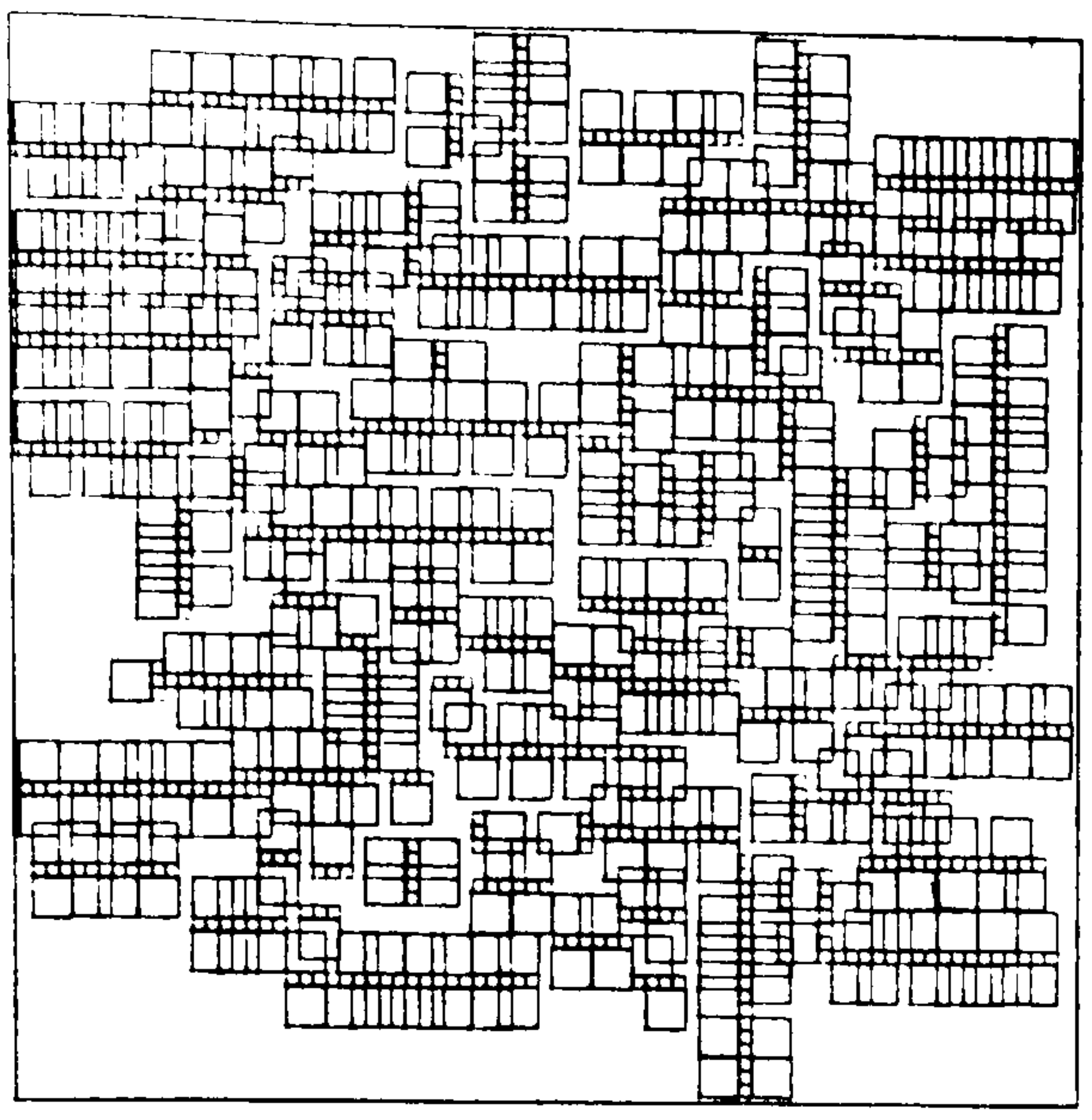


X clustering 0.40
Y clustering 0.20
Overlap allowed 5.00
Y sliding 0.80

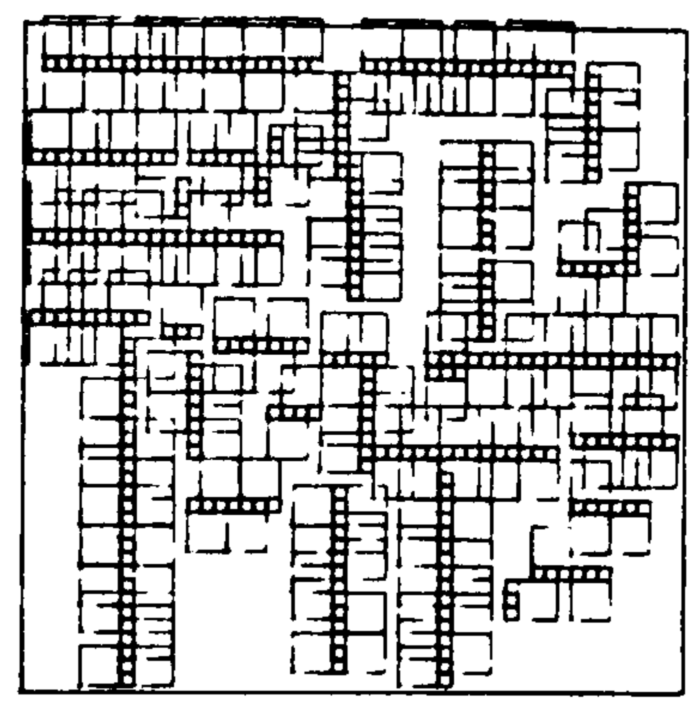




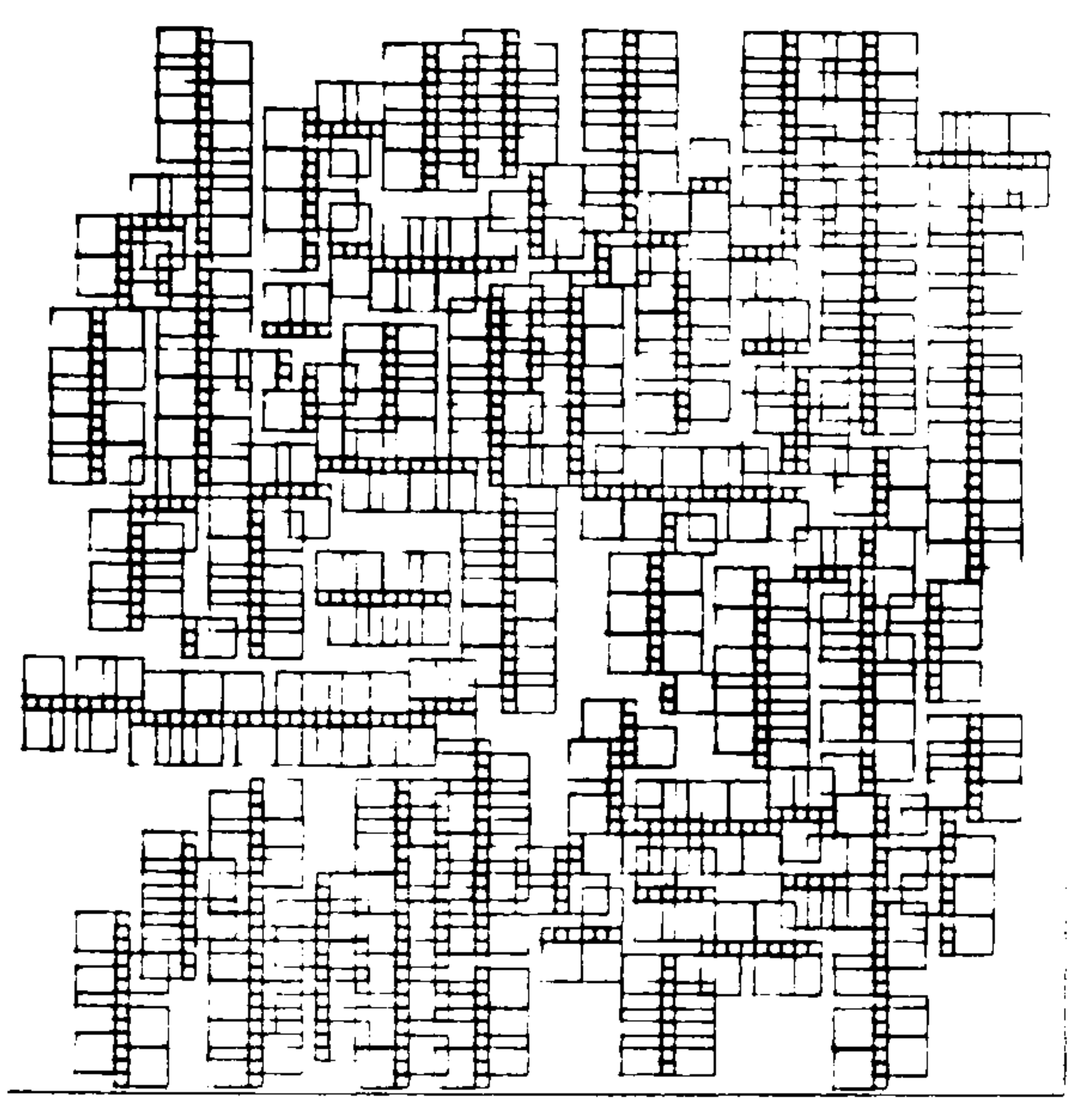
X clustering 0.40
Y clustering 0.80
Overlap allowed 5.00
Y sliding 0.20

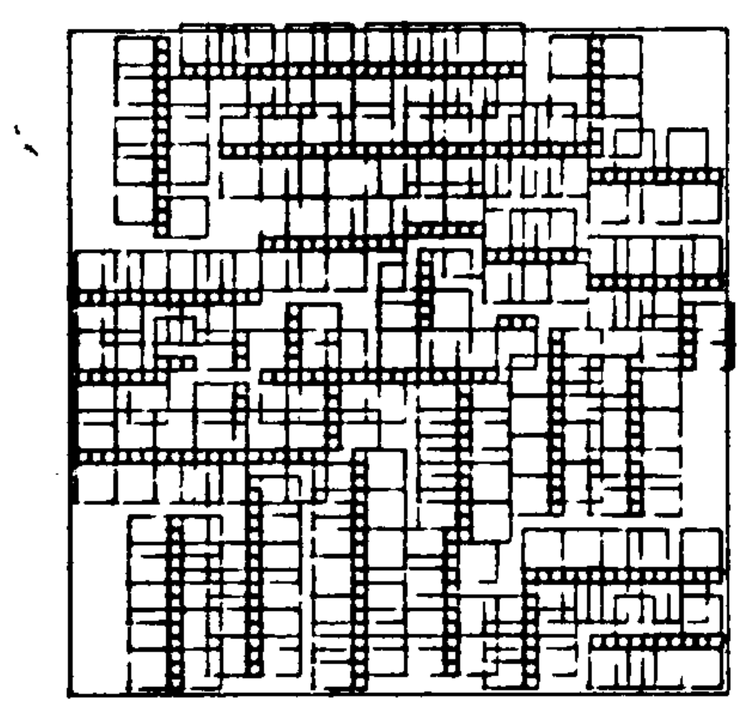


X olustering 0.00
Y olustering 0.60
Overlap allowed 5.00
Y sliding 0.80

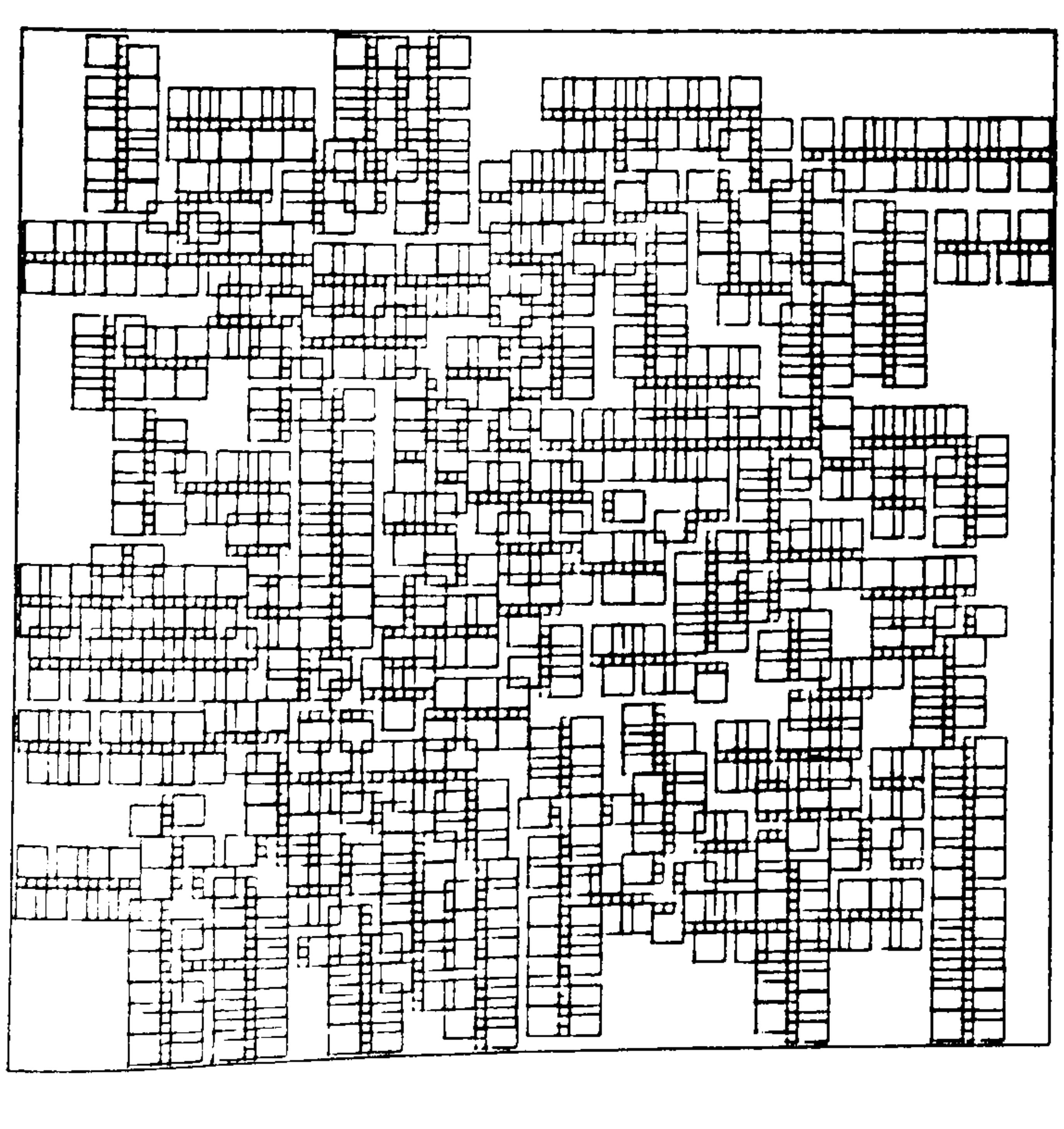


X olustering 0.00
Y olustering 0.60
Overlap allowed 5.00
Y sliding 0.80

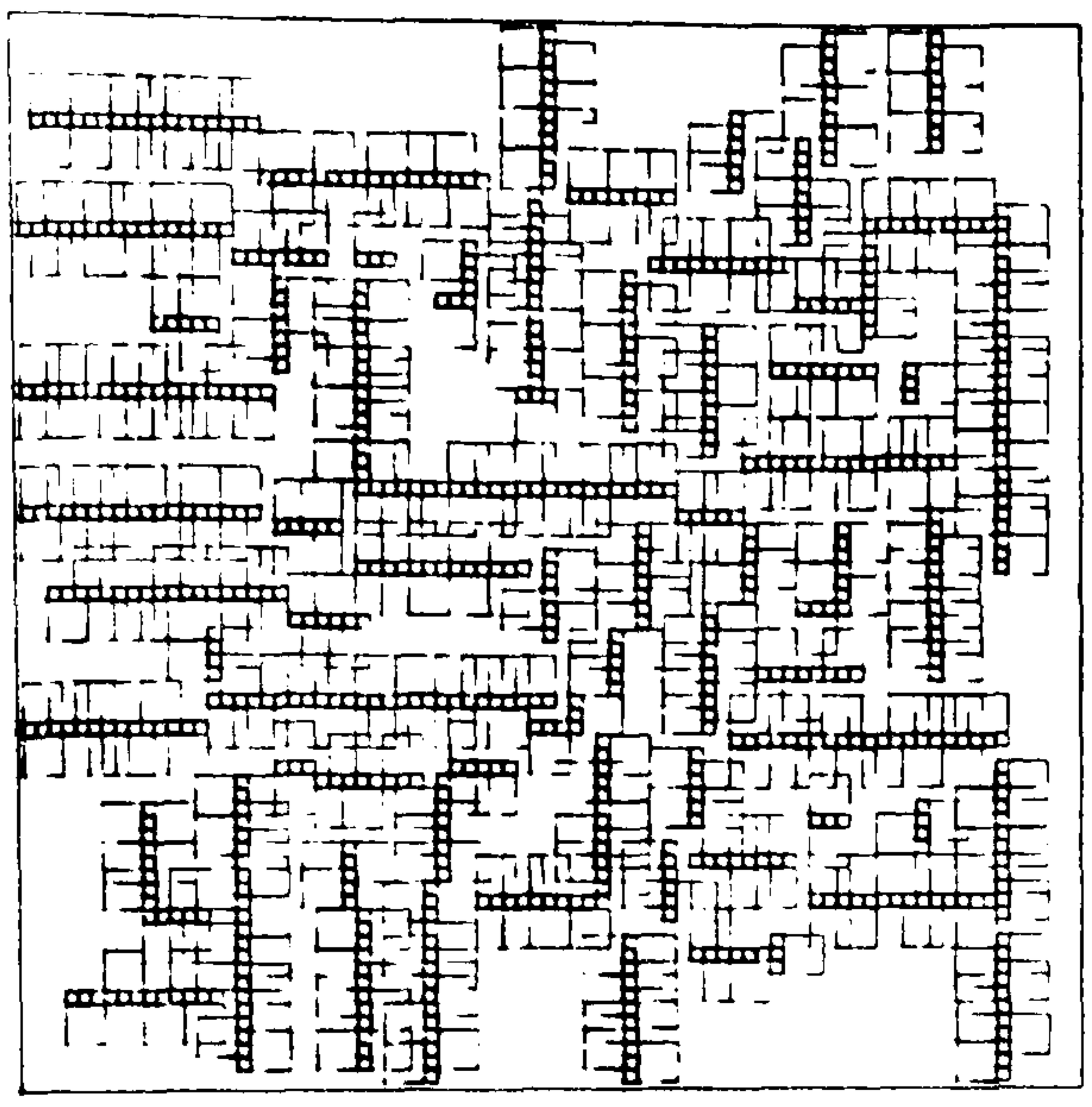




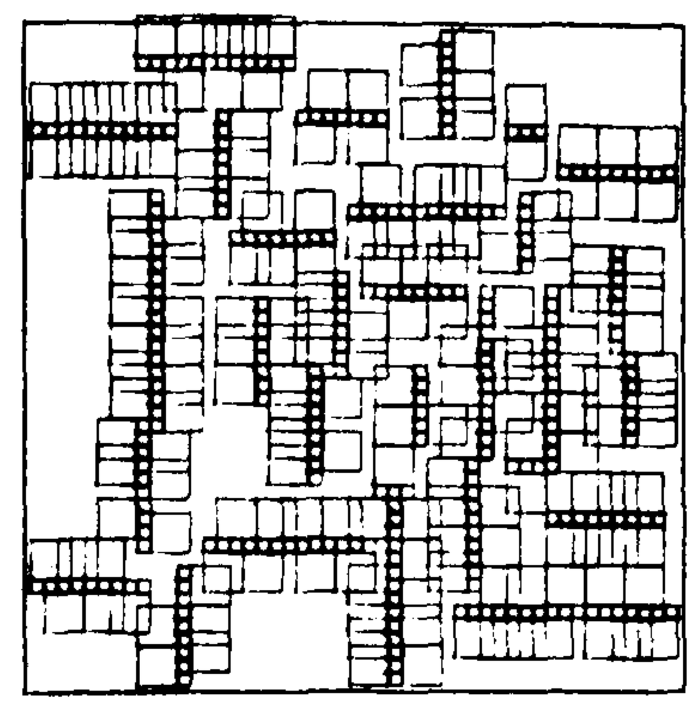
X olustering 0.00
Y olustering 0.60
Overlap allowed 5.00
Y sliding 0.80



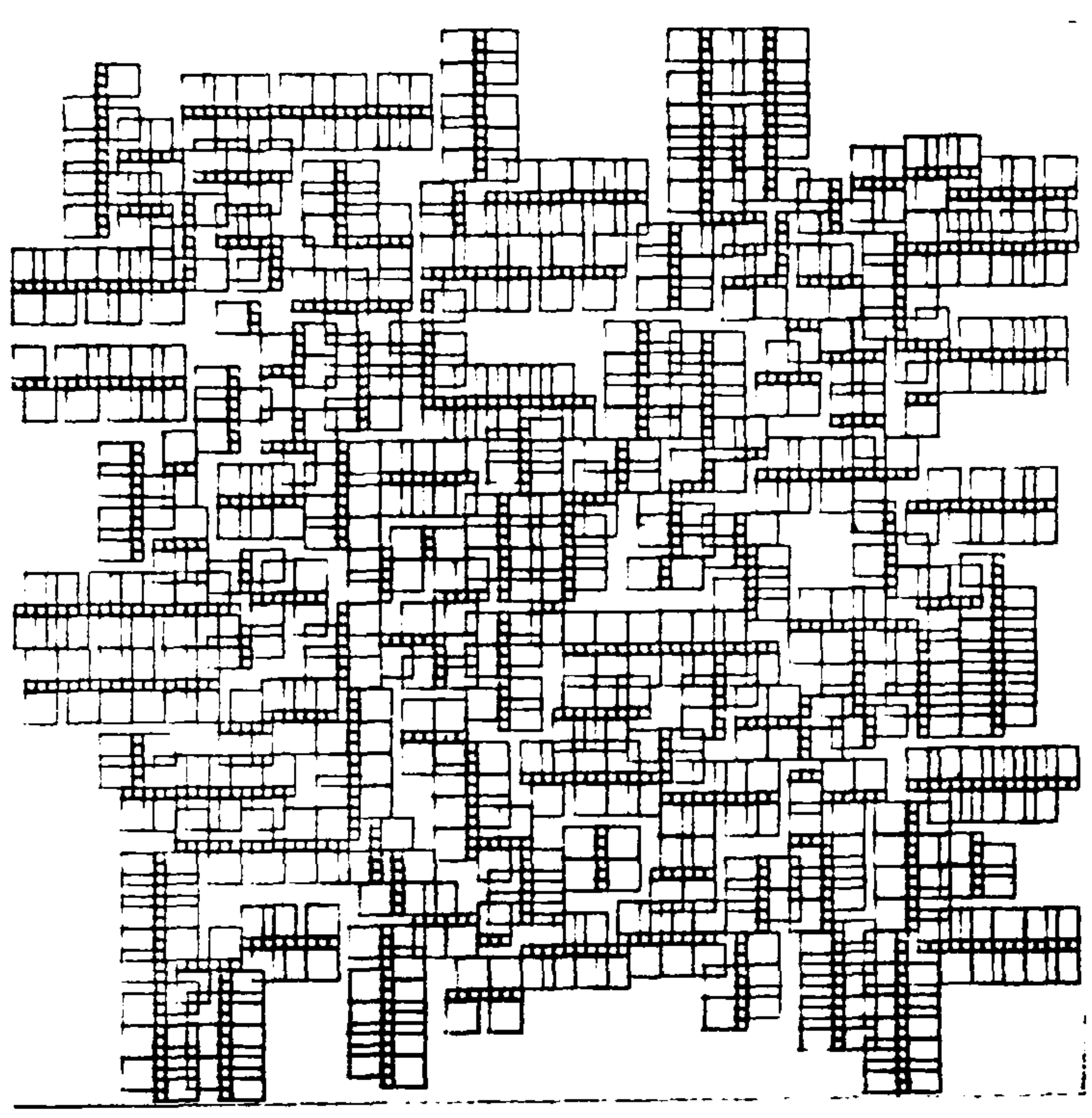
X olustering 0.00
Y olustering 0.60
Overlap allowed 5.00
Y sliding 0.80

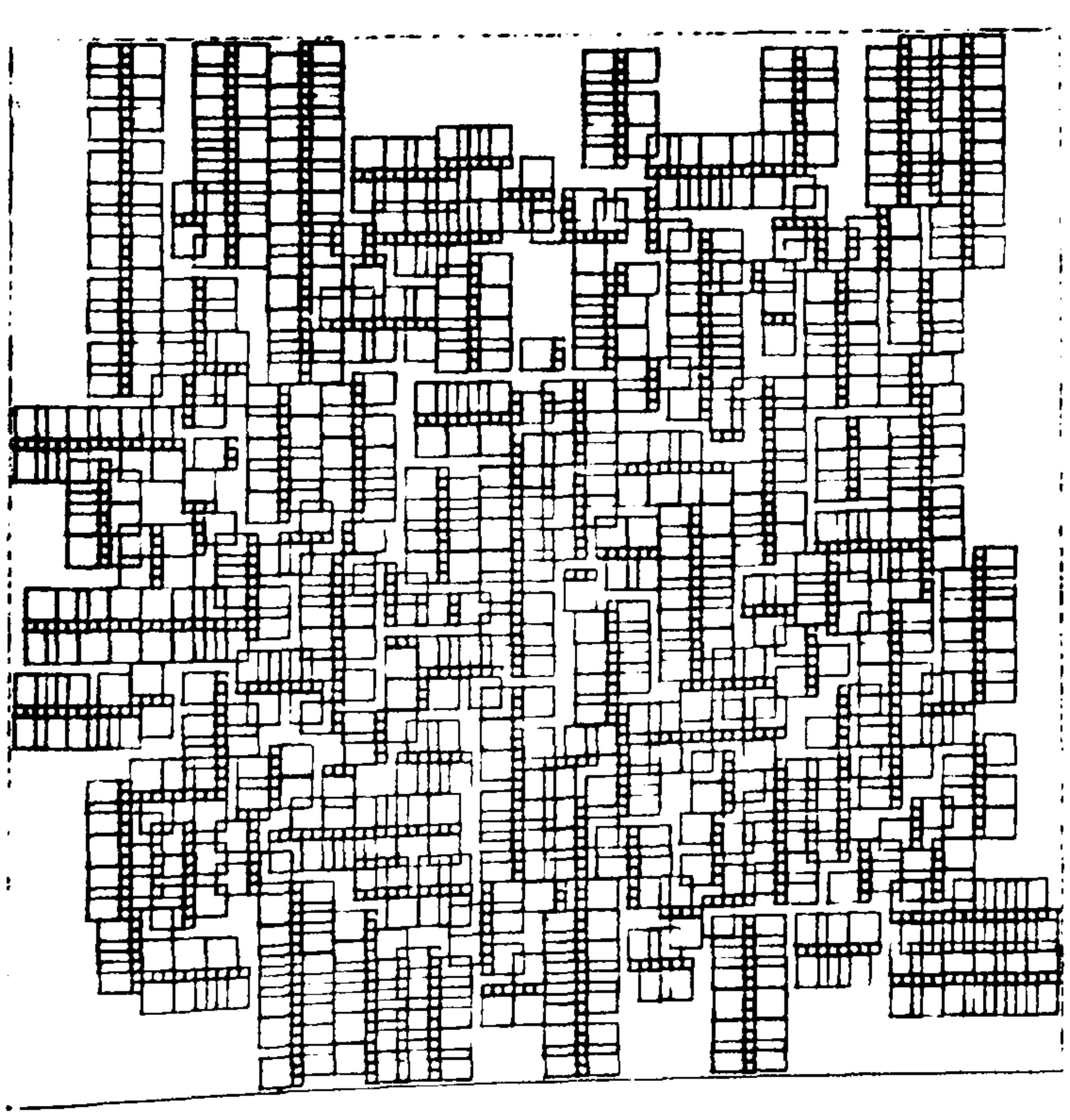


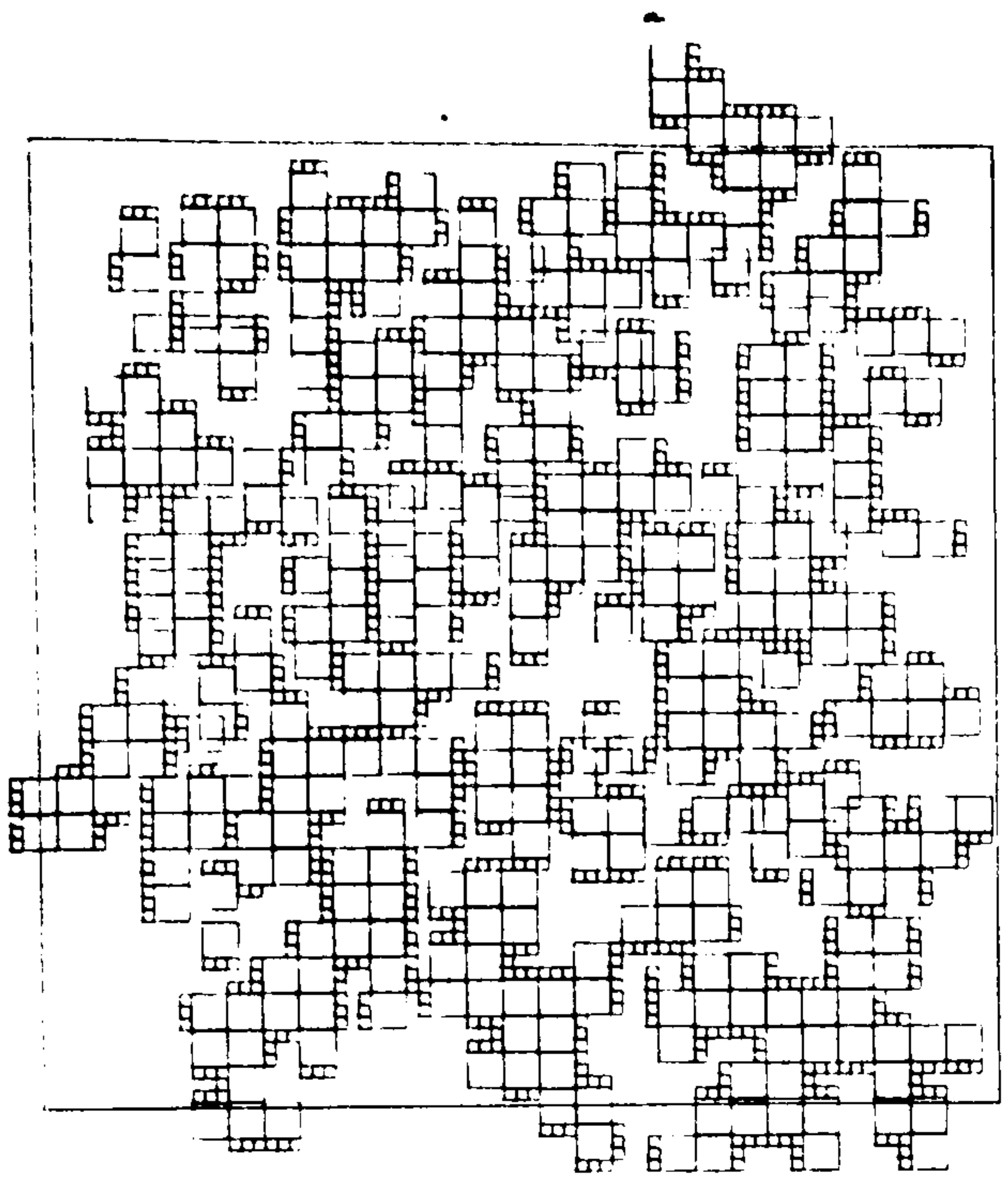
Y clustering 0.00
Y clustering 0.60
Overlap all wed 5.00
Y sliding 0.8

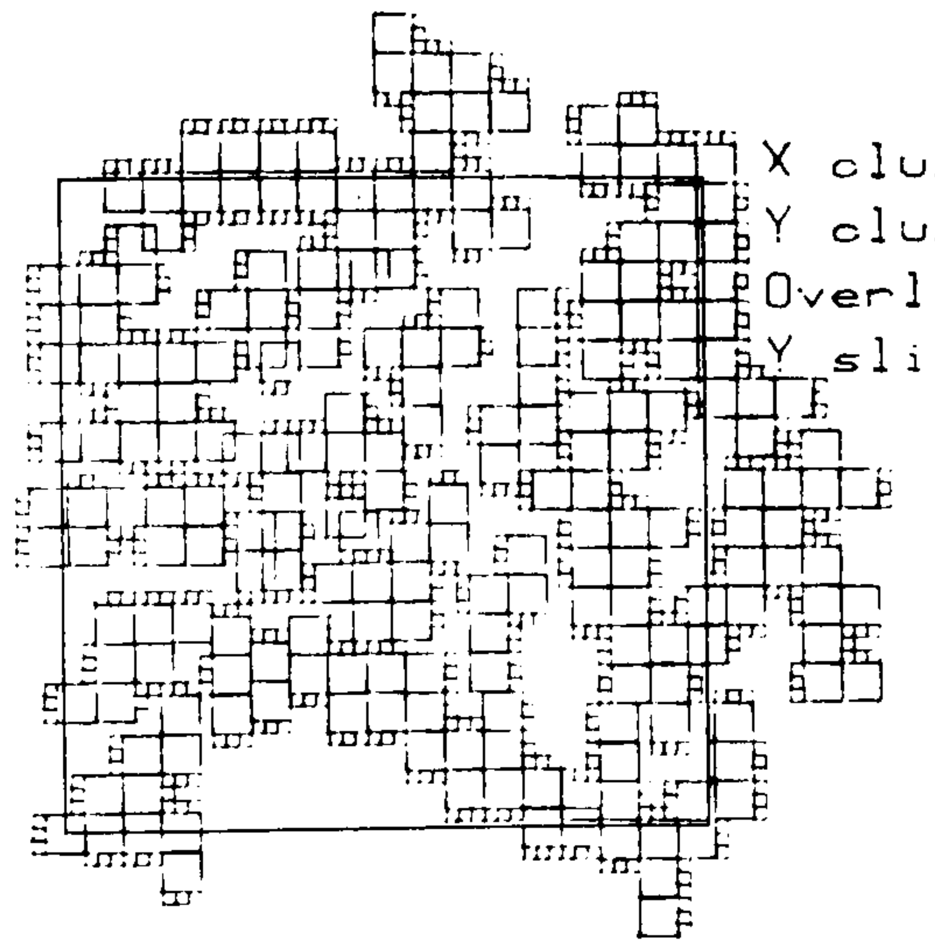


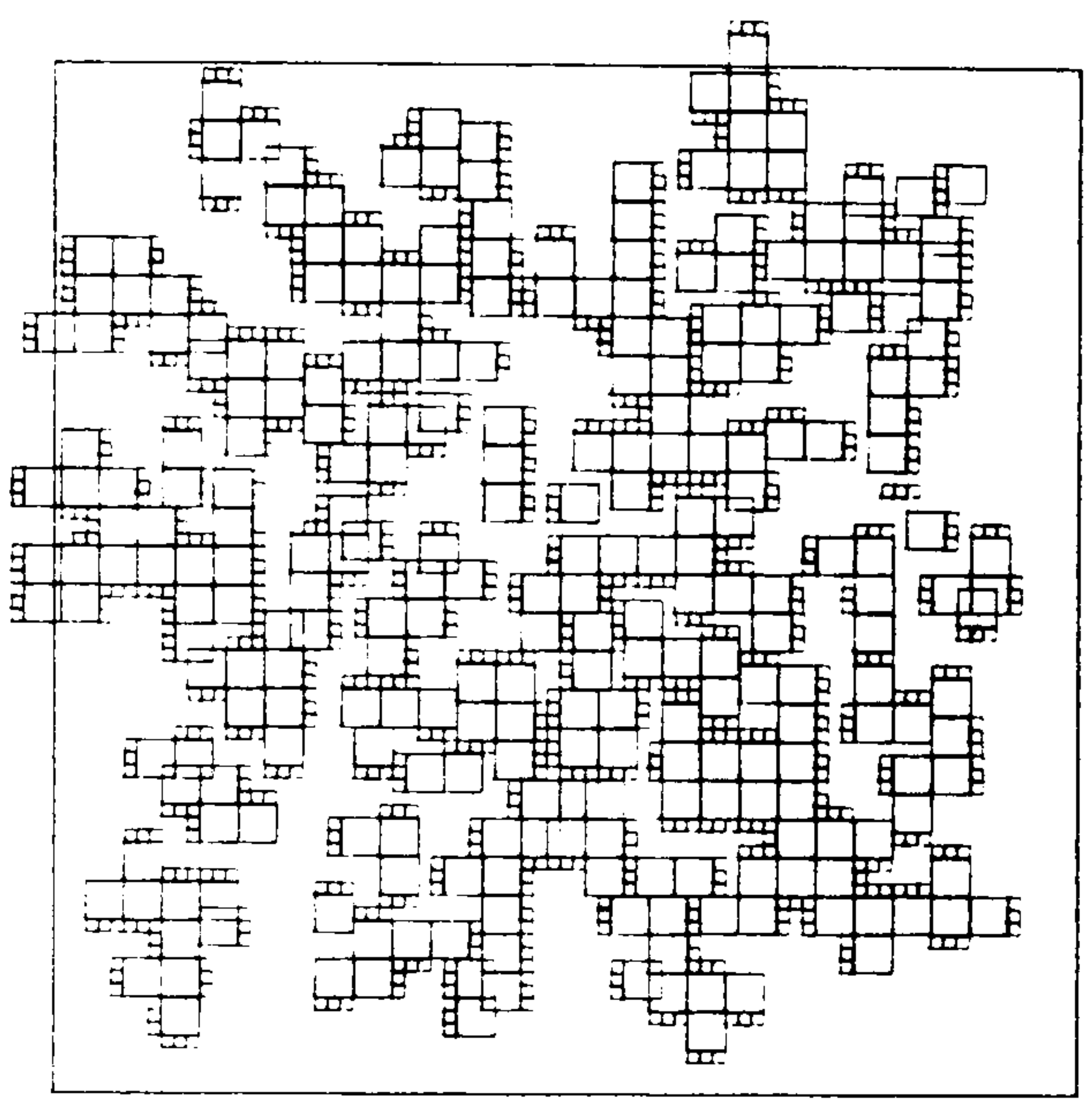
X clustering 0.00
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.80

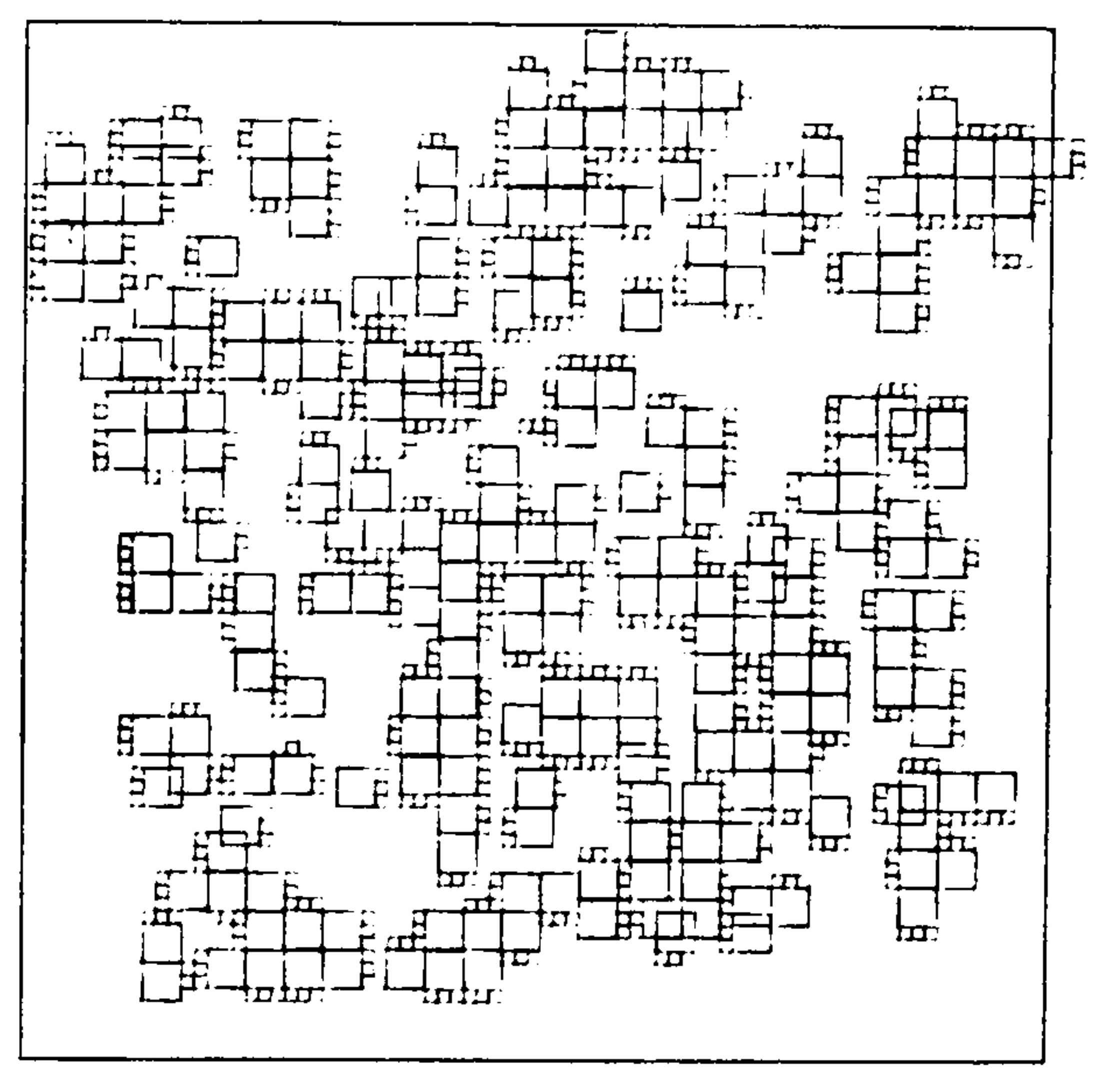


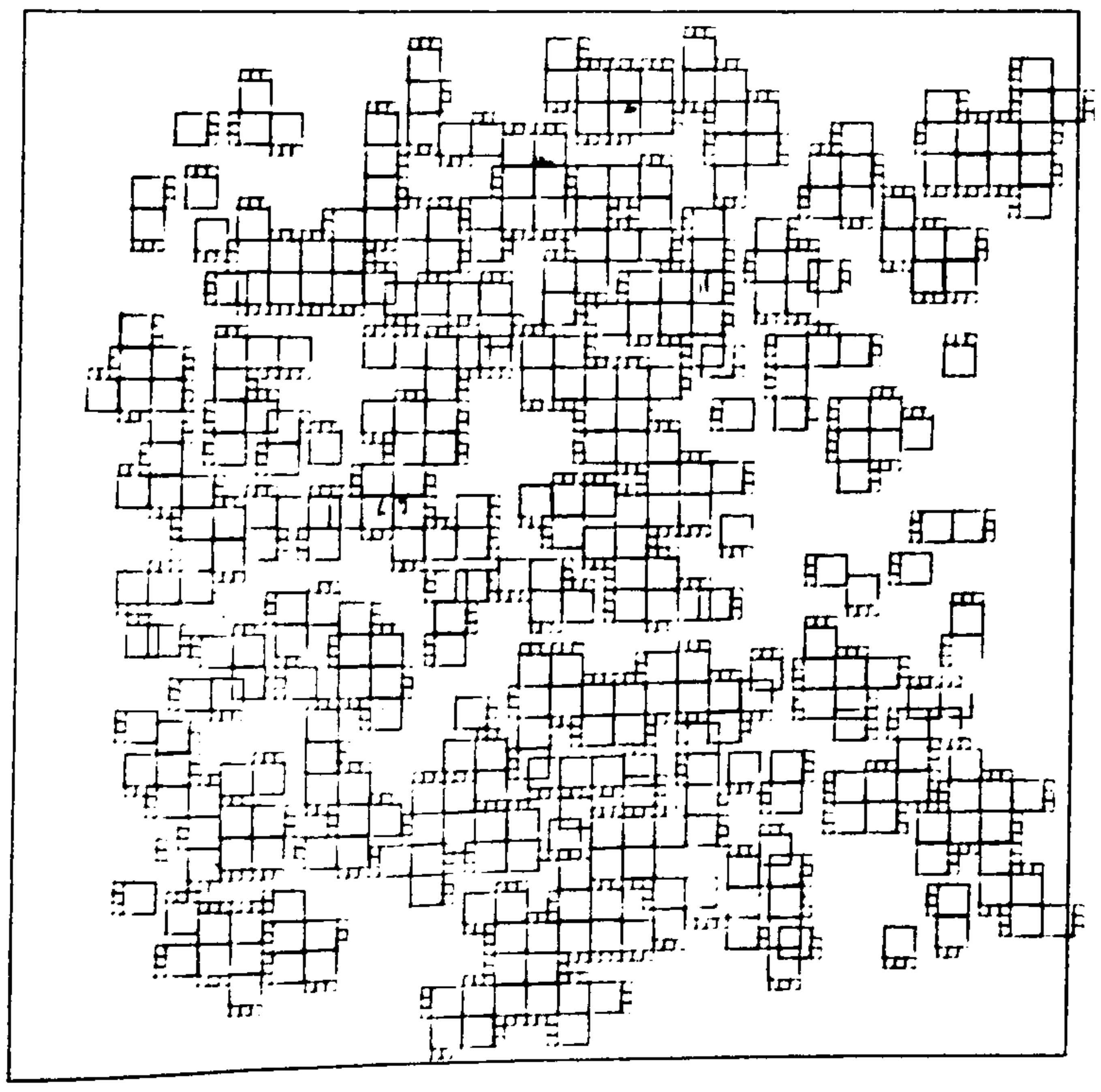


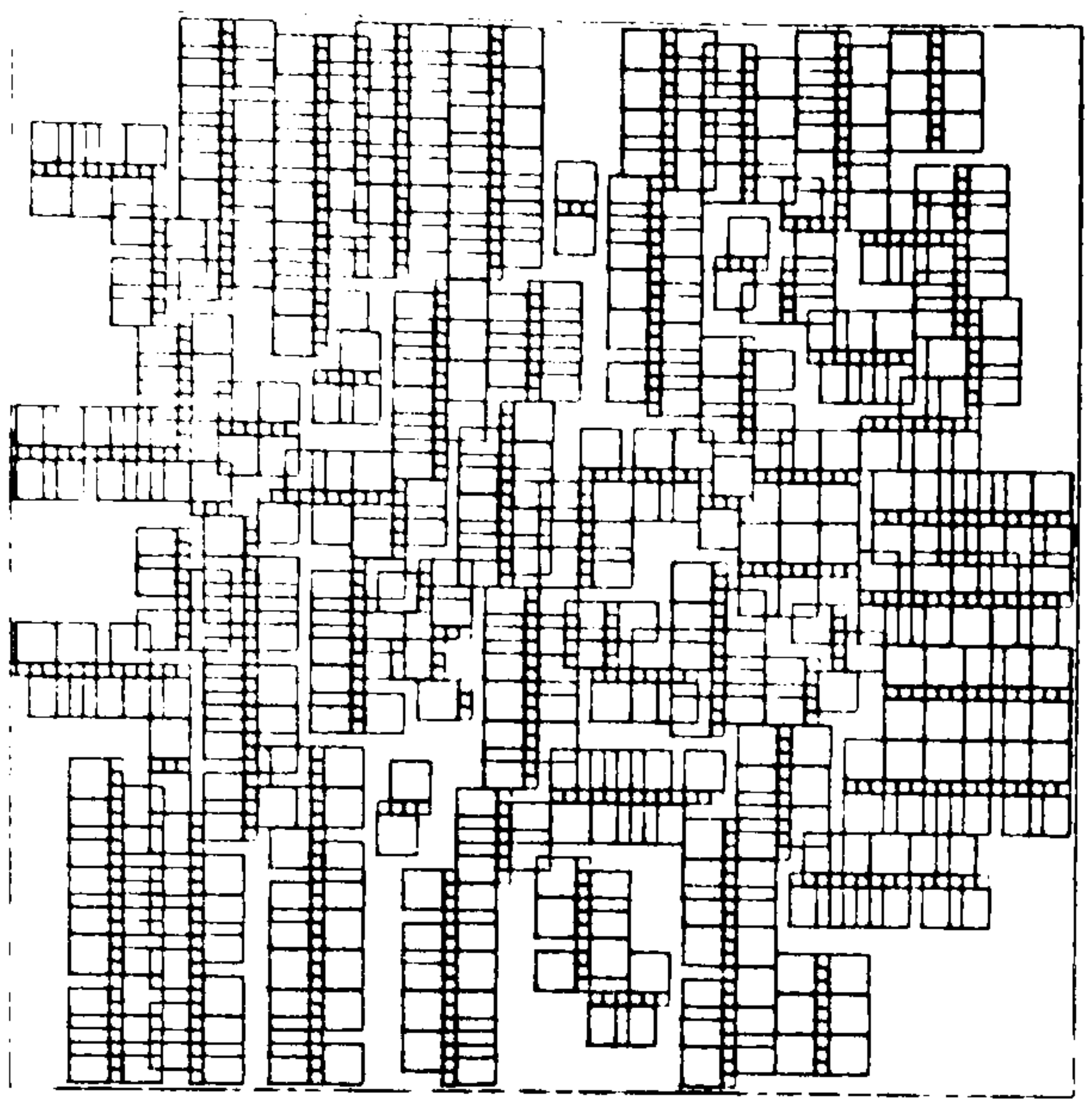

X clustering 0.60
Y clustering 0.00
Overlap allowed 5.00
Y sliding 0.80


X clustering 0.60
Y clustering 0.00
Overlap allowed 5.00
Y sliding 0.80

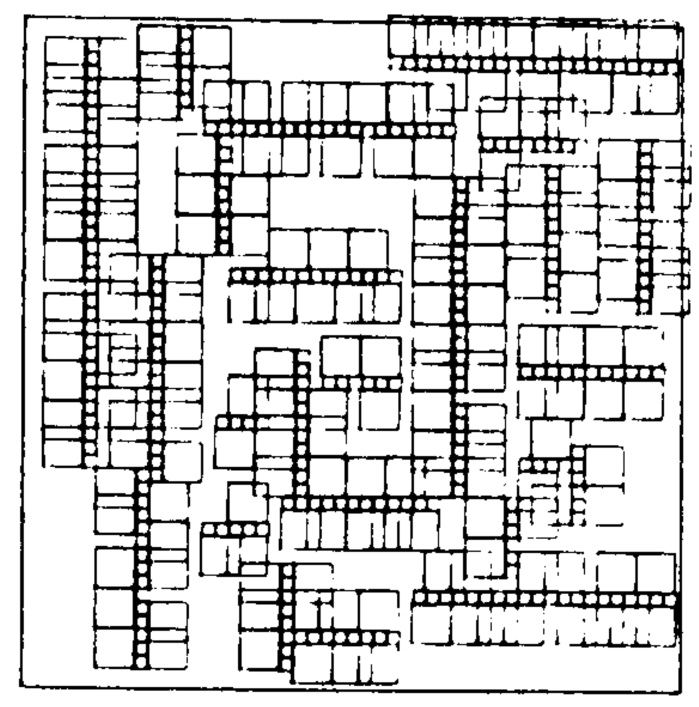

X clustering 0.60
Y clustering 0.00
Overlap allowed 5.00
Y sliding 0.80


X clustering 0.60
Y clustering 0.00
Overlap allowed 5.00
Y sliding 0.80

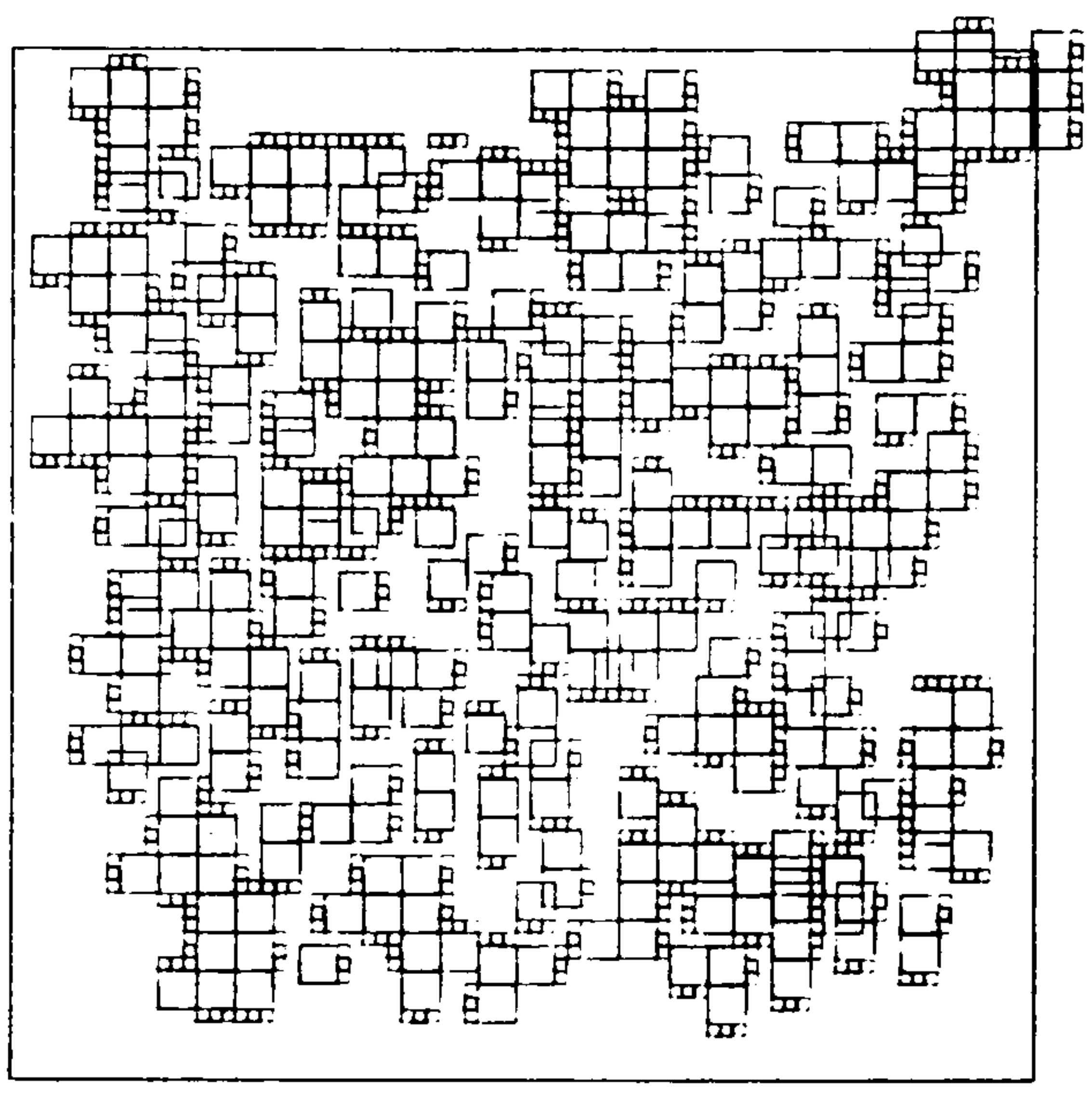

X clustering 0.60
Y clustering 0.00
Overlap allowed 5.00
Y sliding 0.80



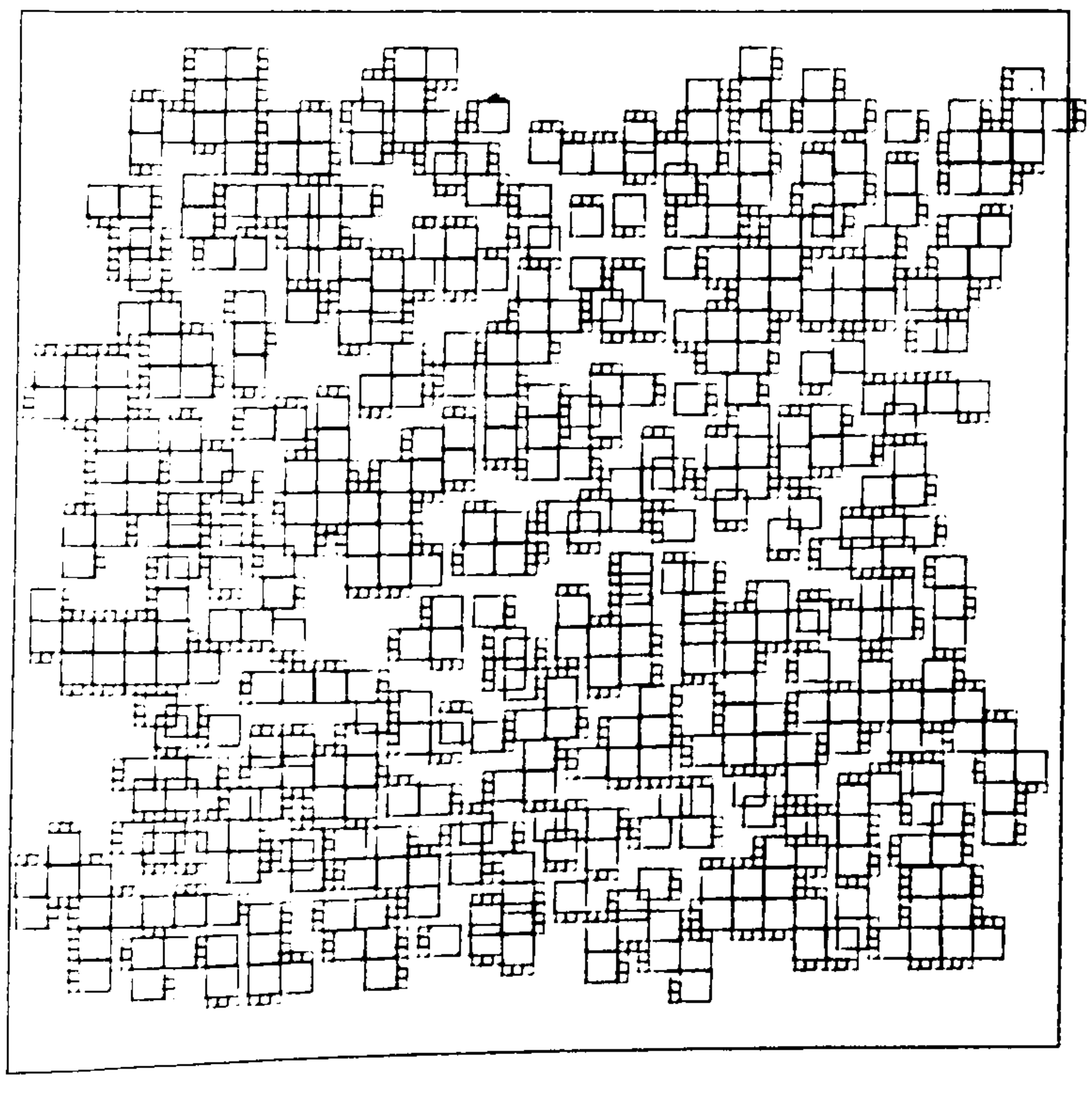
X clustering 0.00
Y clustering [illegible]
Overlap allowed 5.00
Y sliding [illegible]



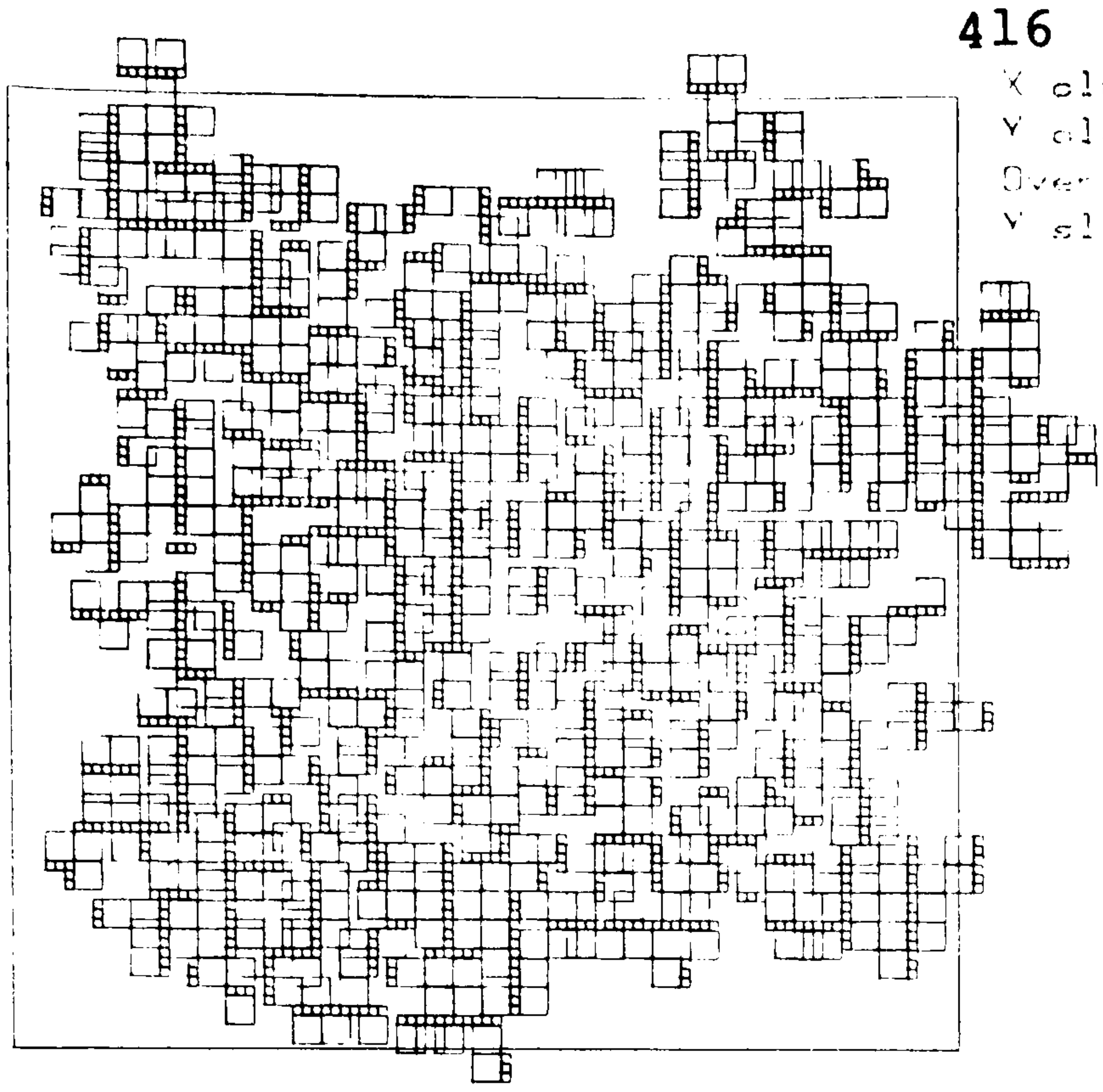
X clustering 0.00
Y clustering 0.70
Overlap allowed 5.00
Y sliding 0.80

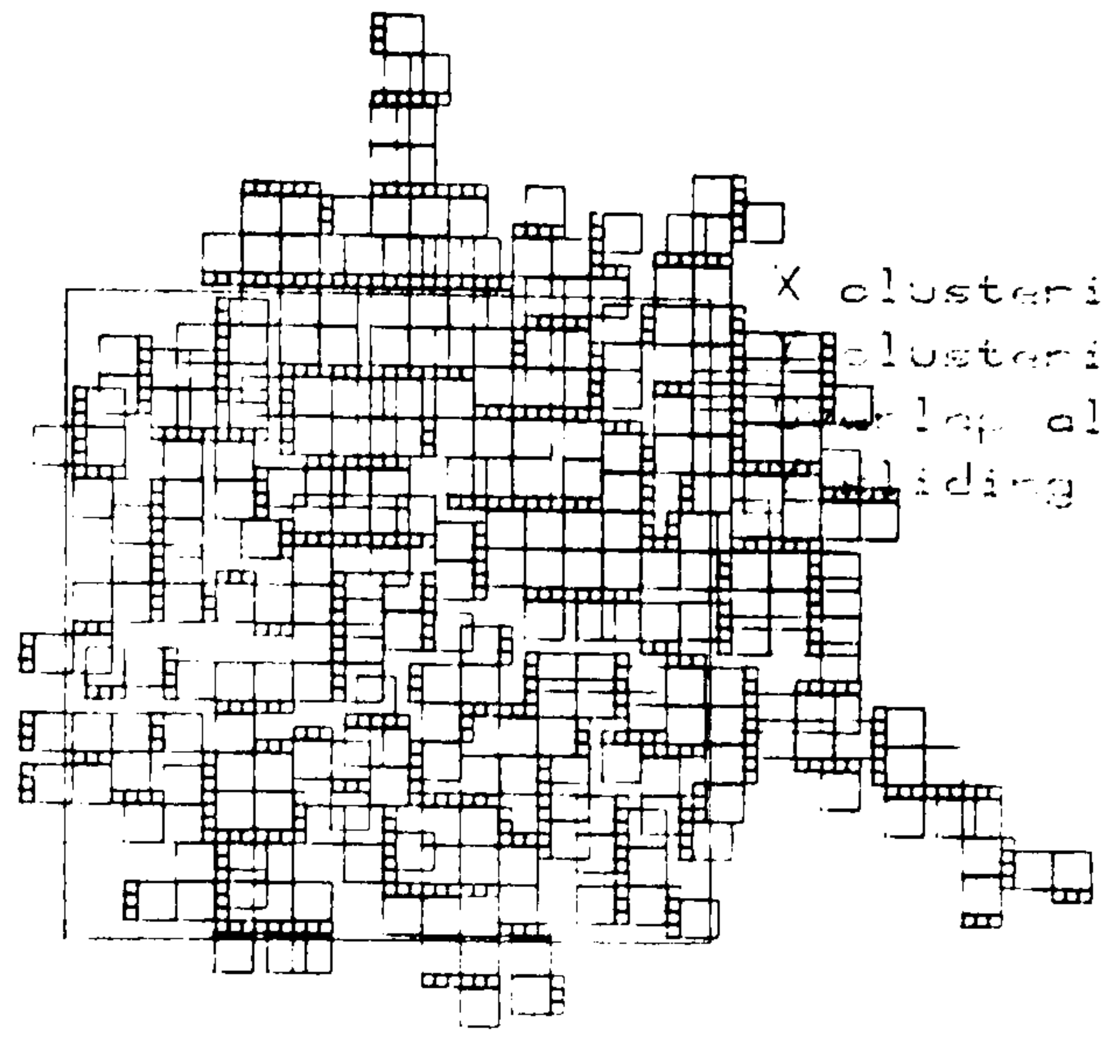


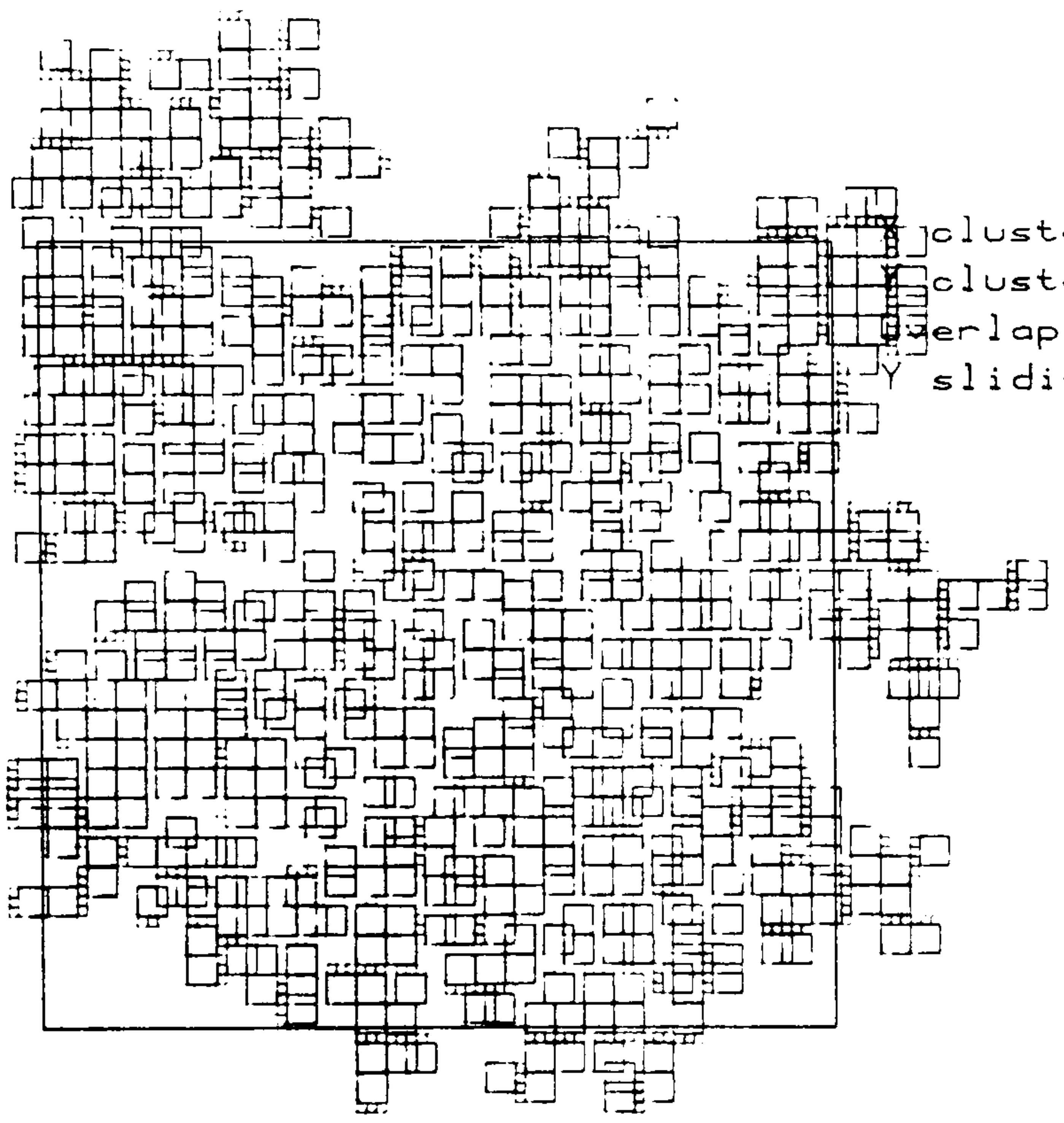
X clustering 0.40
Y clustering 0.00
Overlap allowed 5.00
Y sliding 0.80

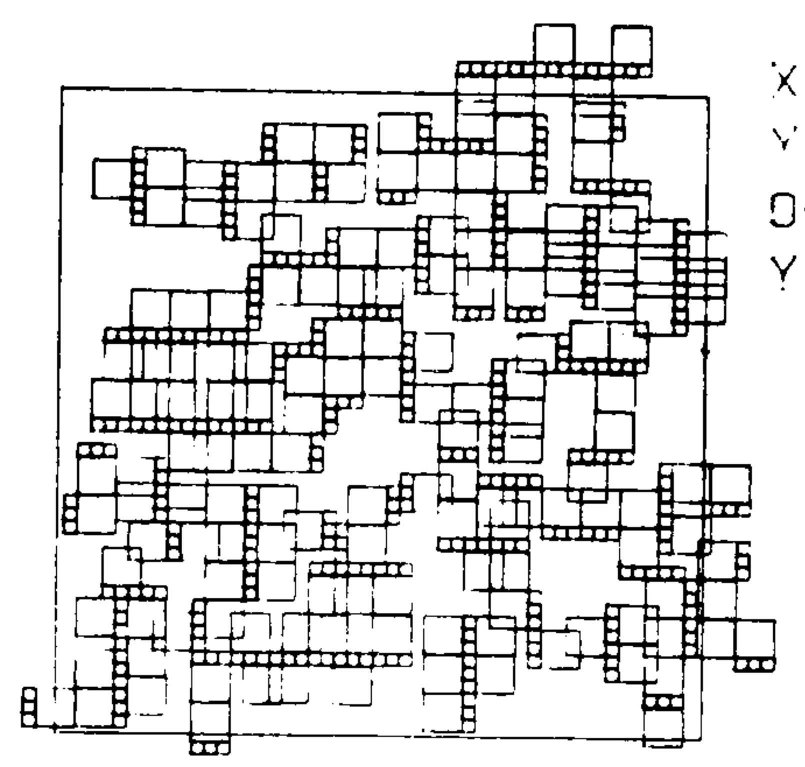


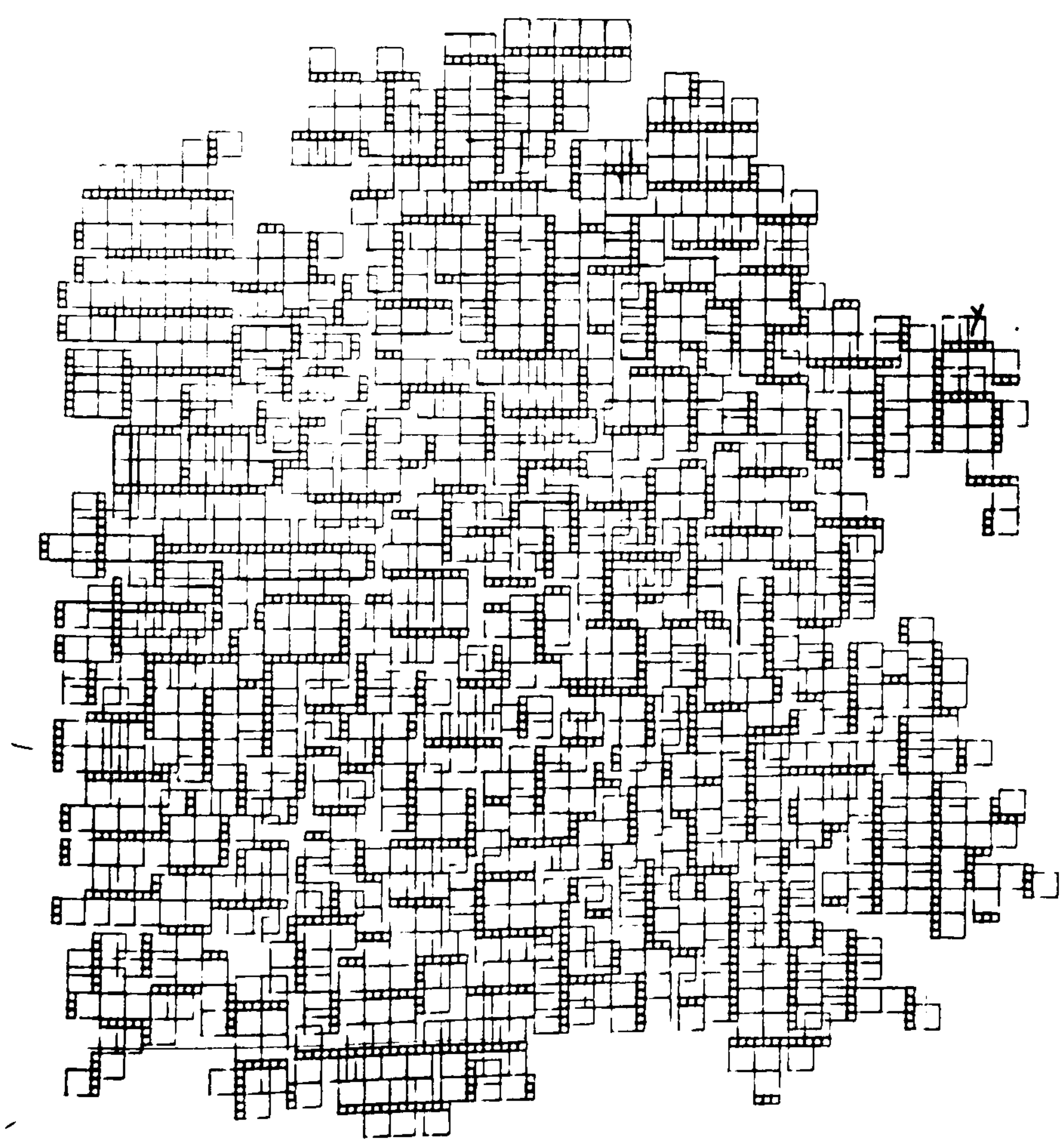
X clustering 0.40
Y clustering 0.00
Overlap allowed 5.00
Y sliding 0.80

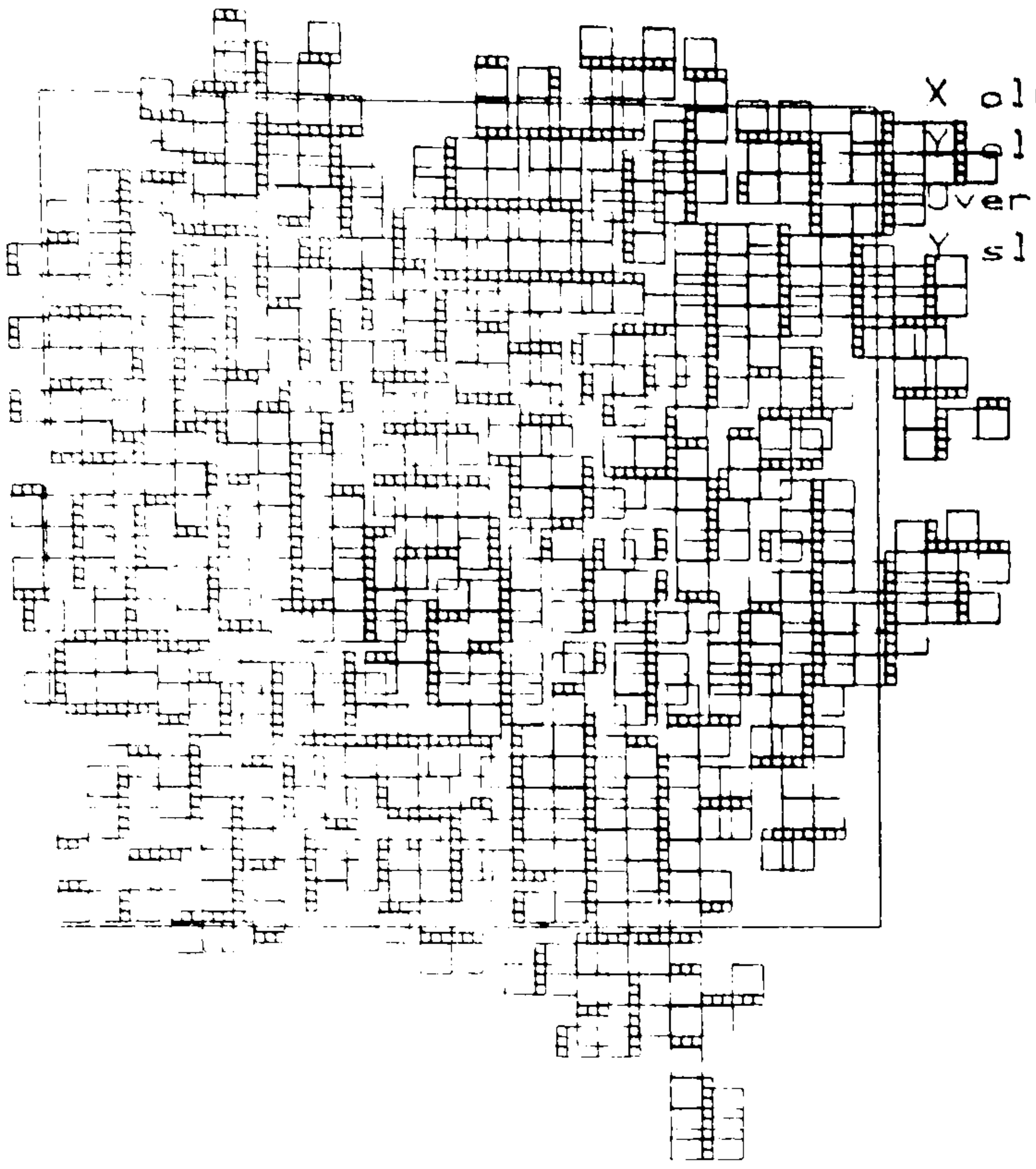

X clustering 0.60
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.80


X clustering 0.60
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.80

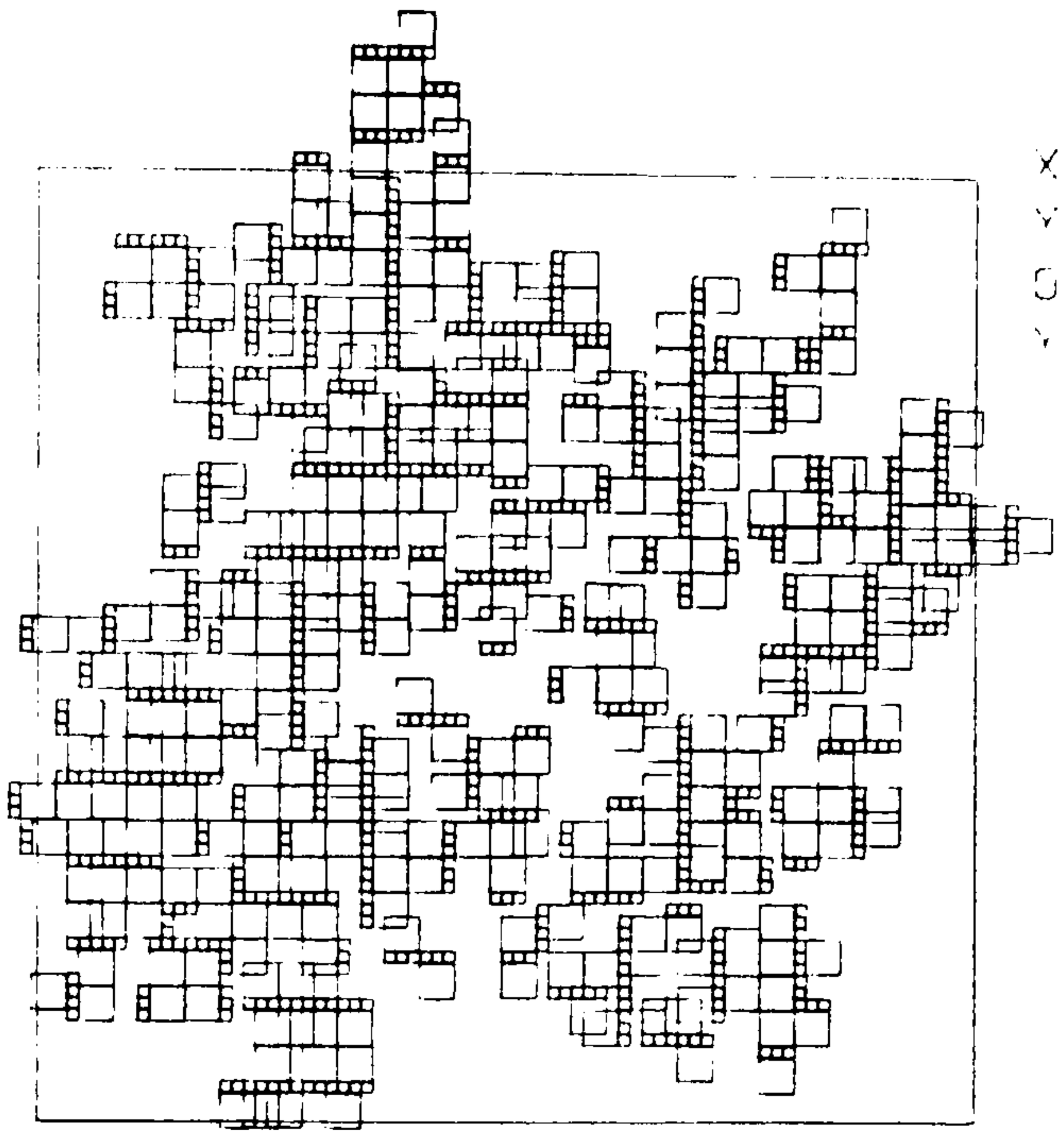

X clustering 0.60
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.80


X clustering 0.60
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.80

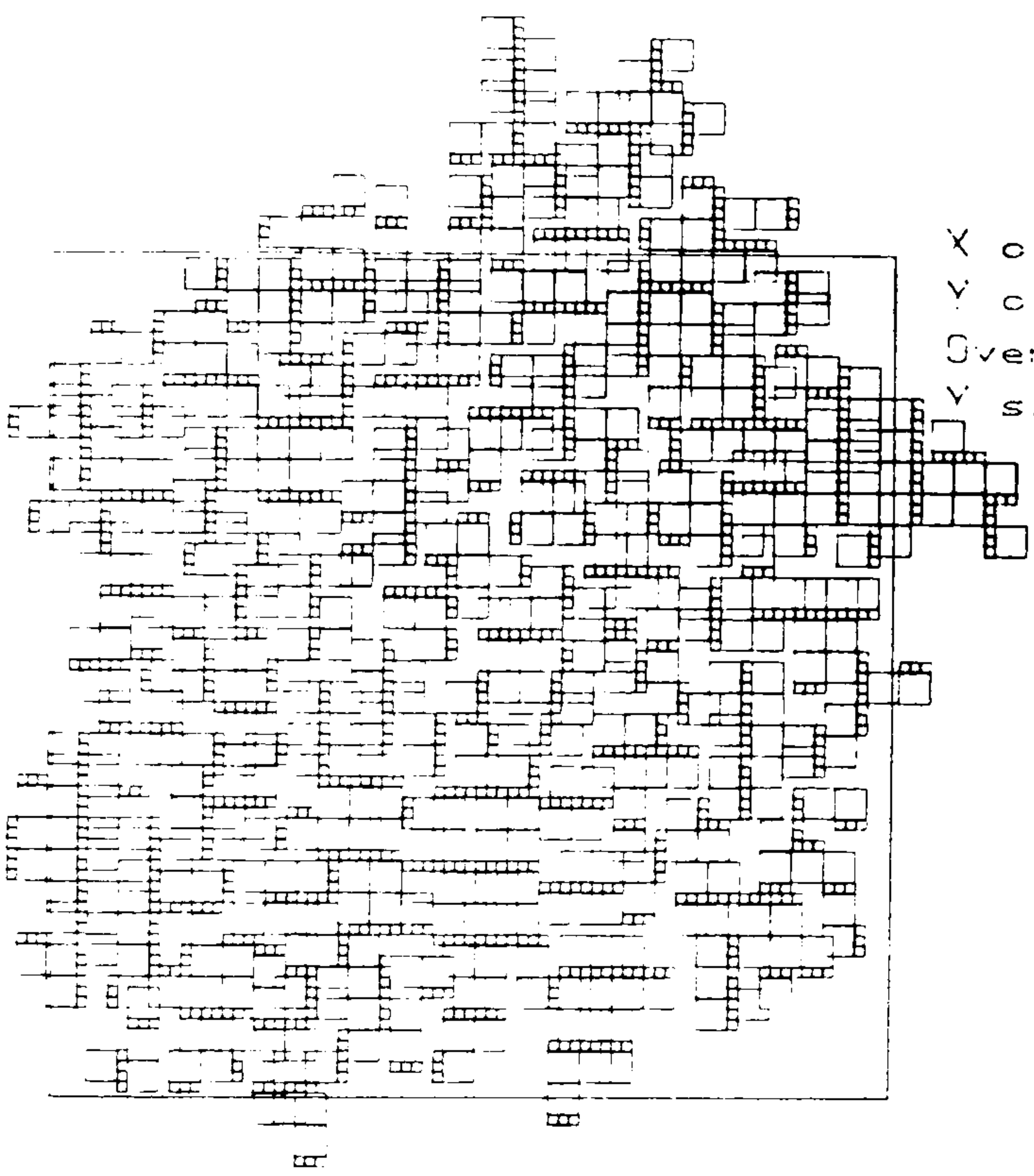




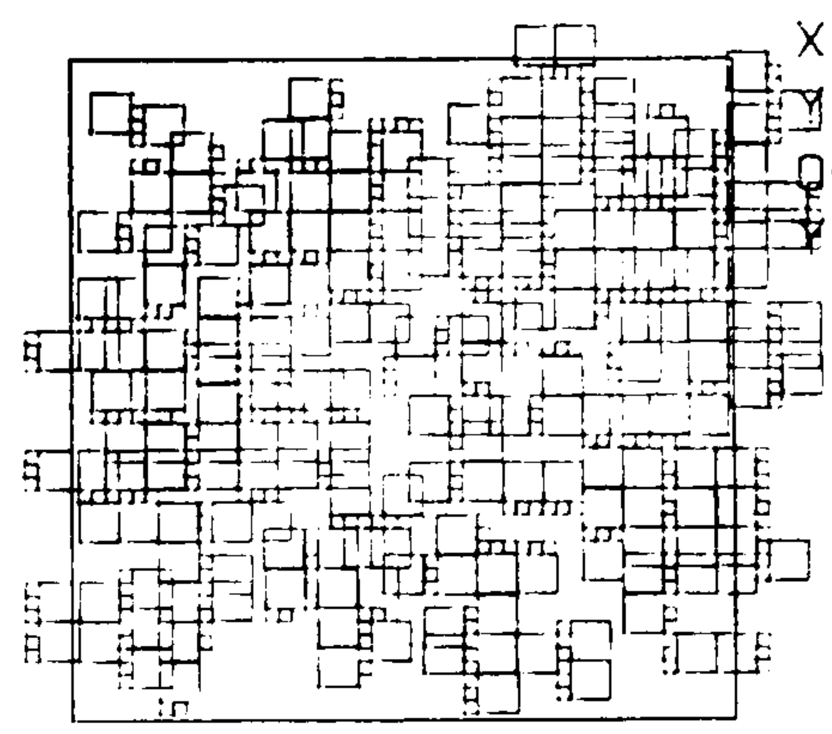
X clustering 0.60
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.80



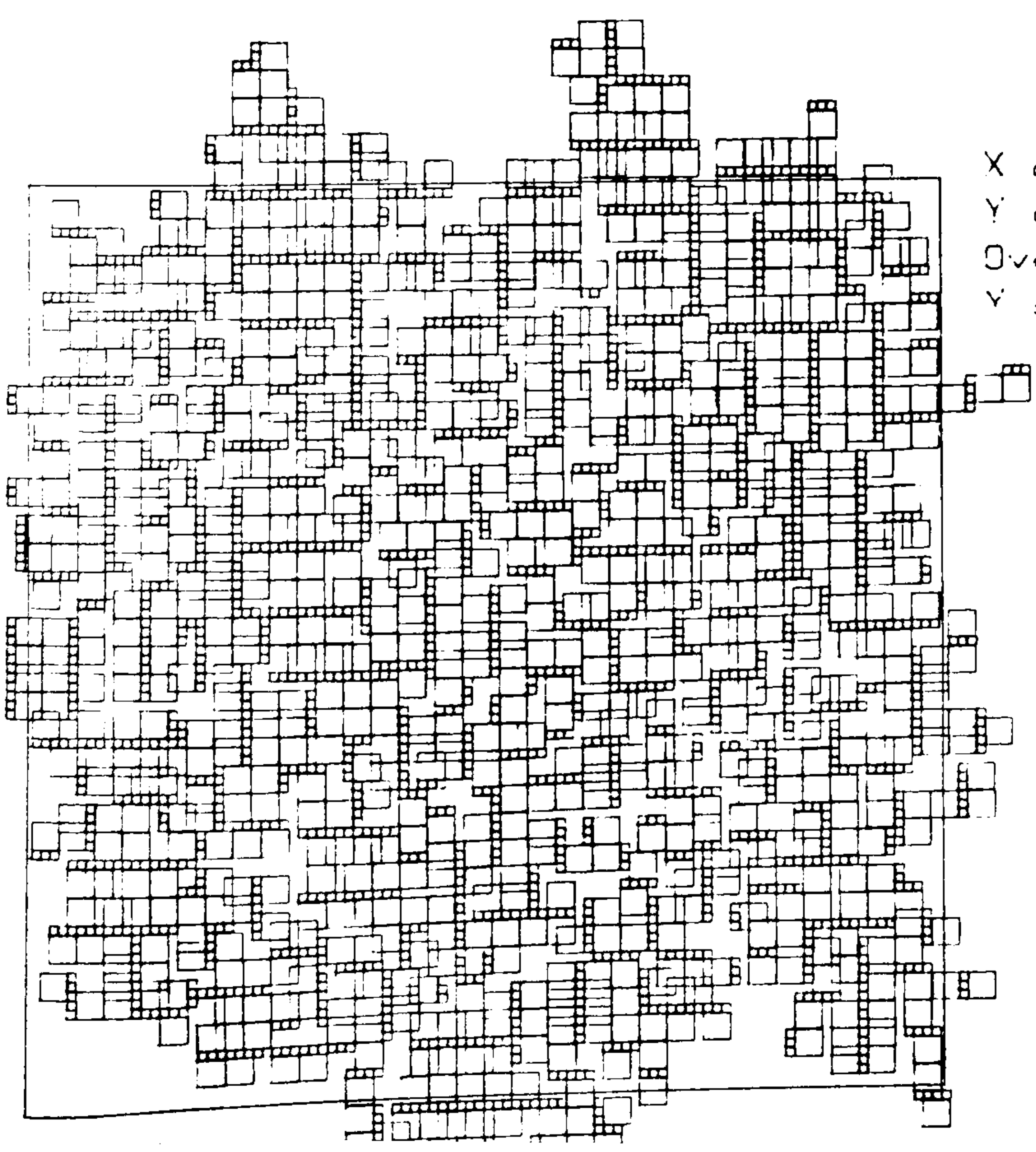
X clustering 0.60
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.80



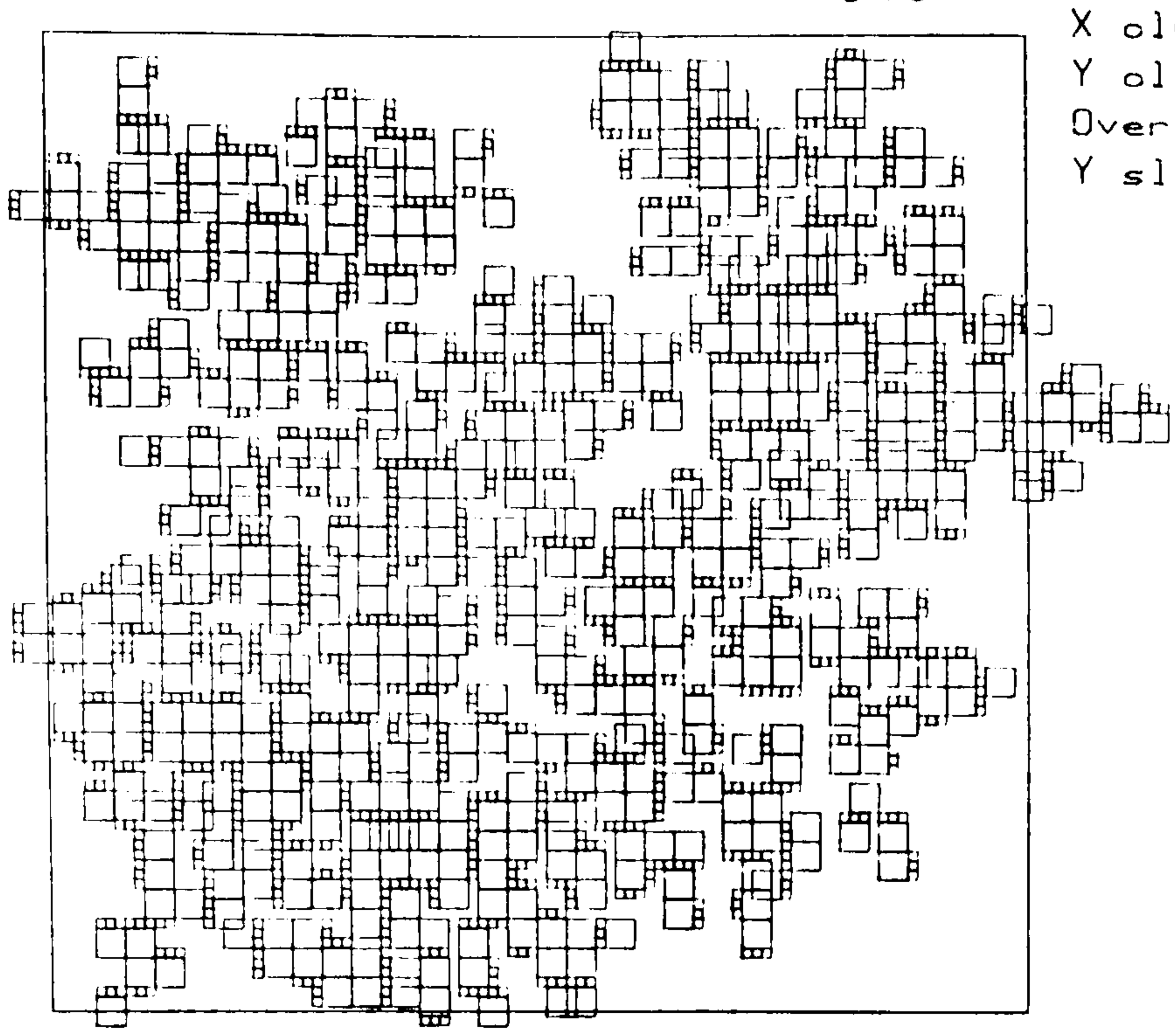
X clustering 0.60
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.80



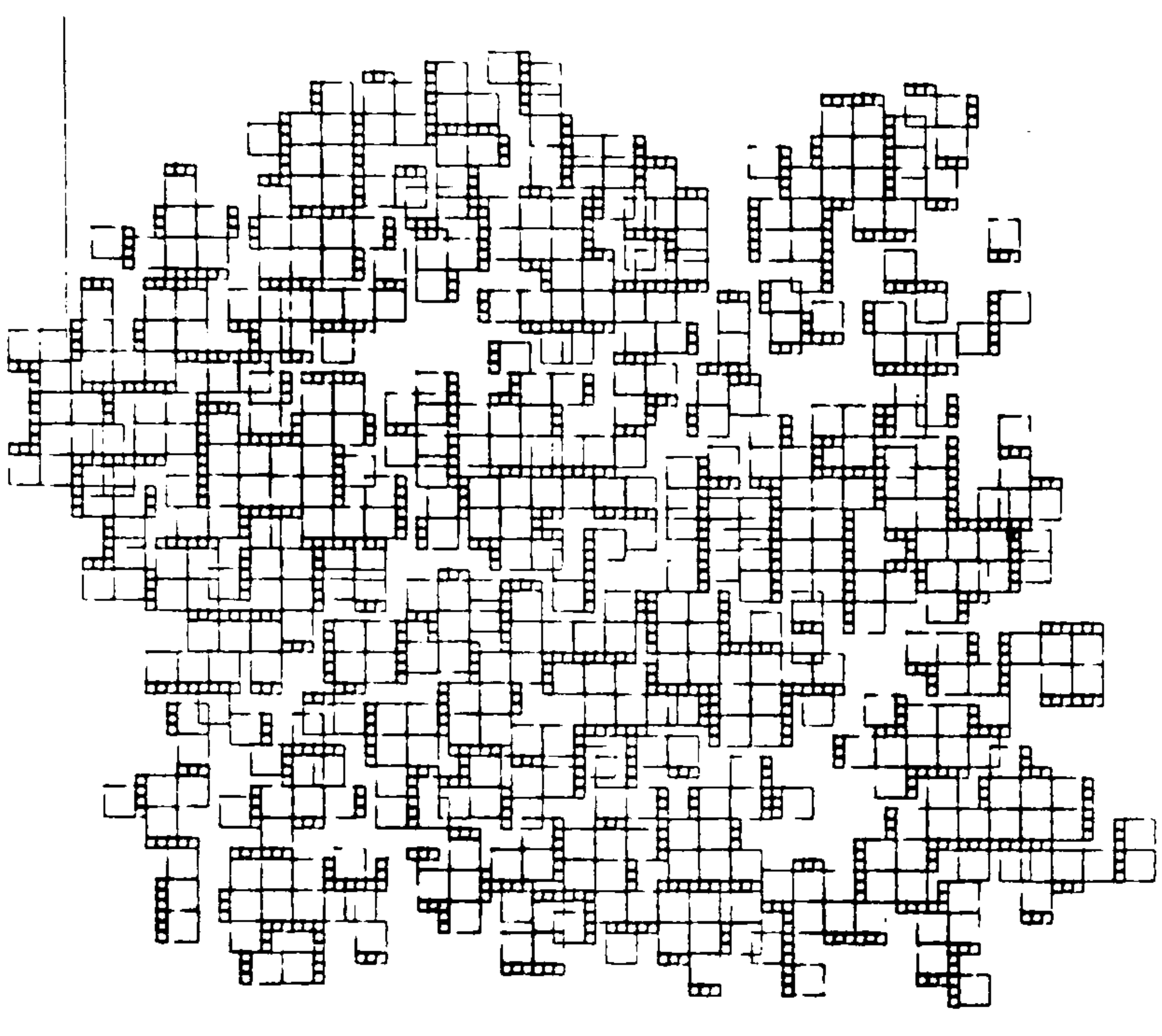
X clustering 0.60
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.80

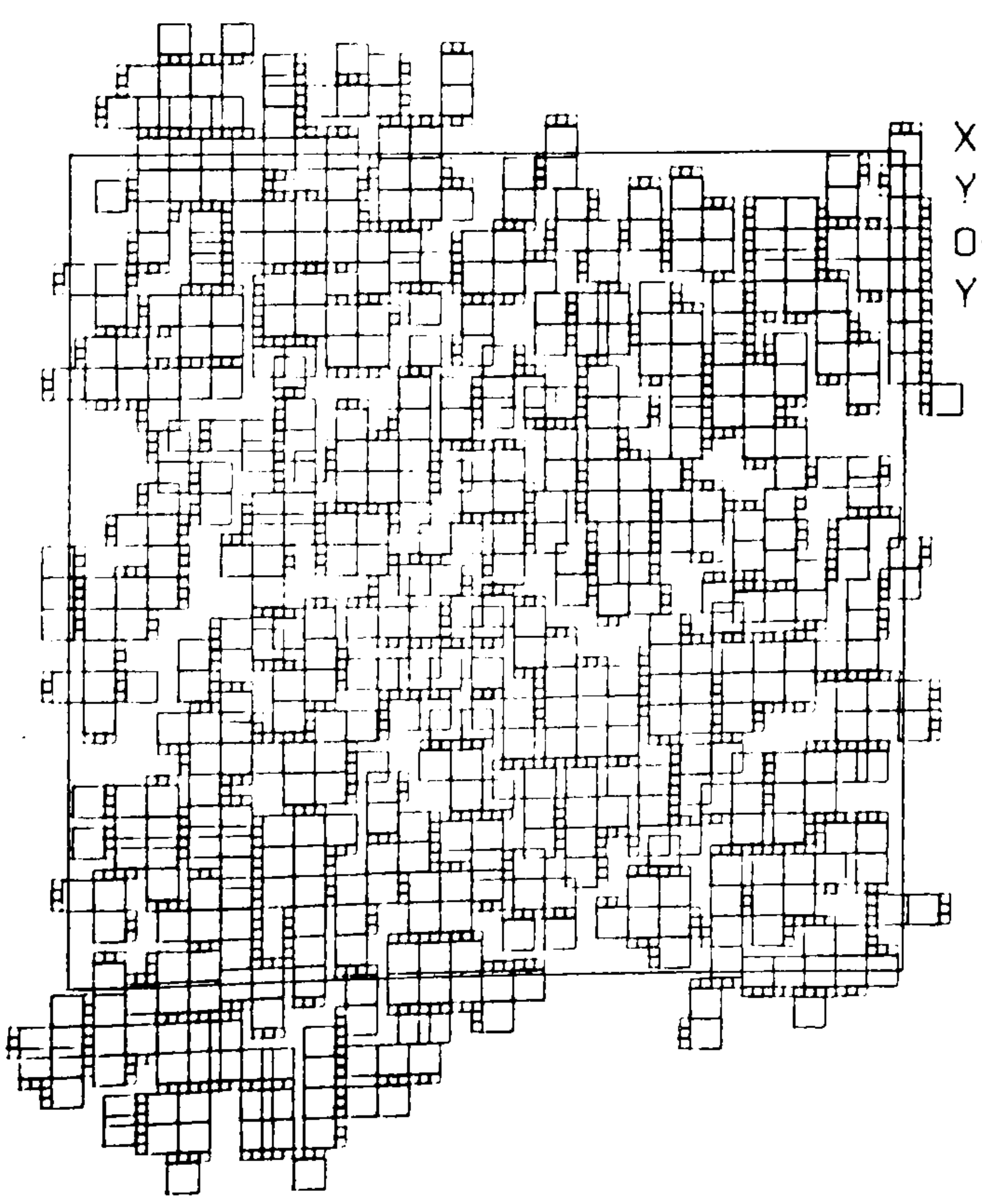


X clustering 0.60
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.80

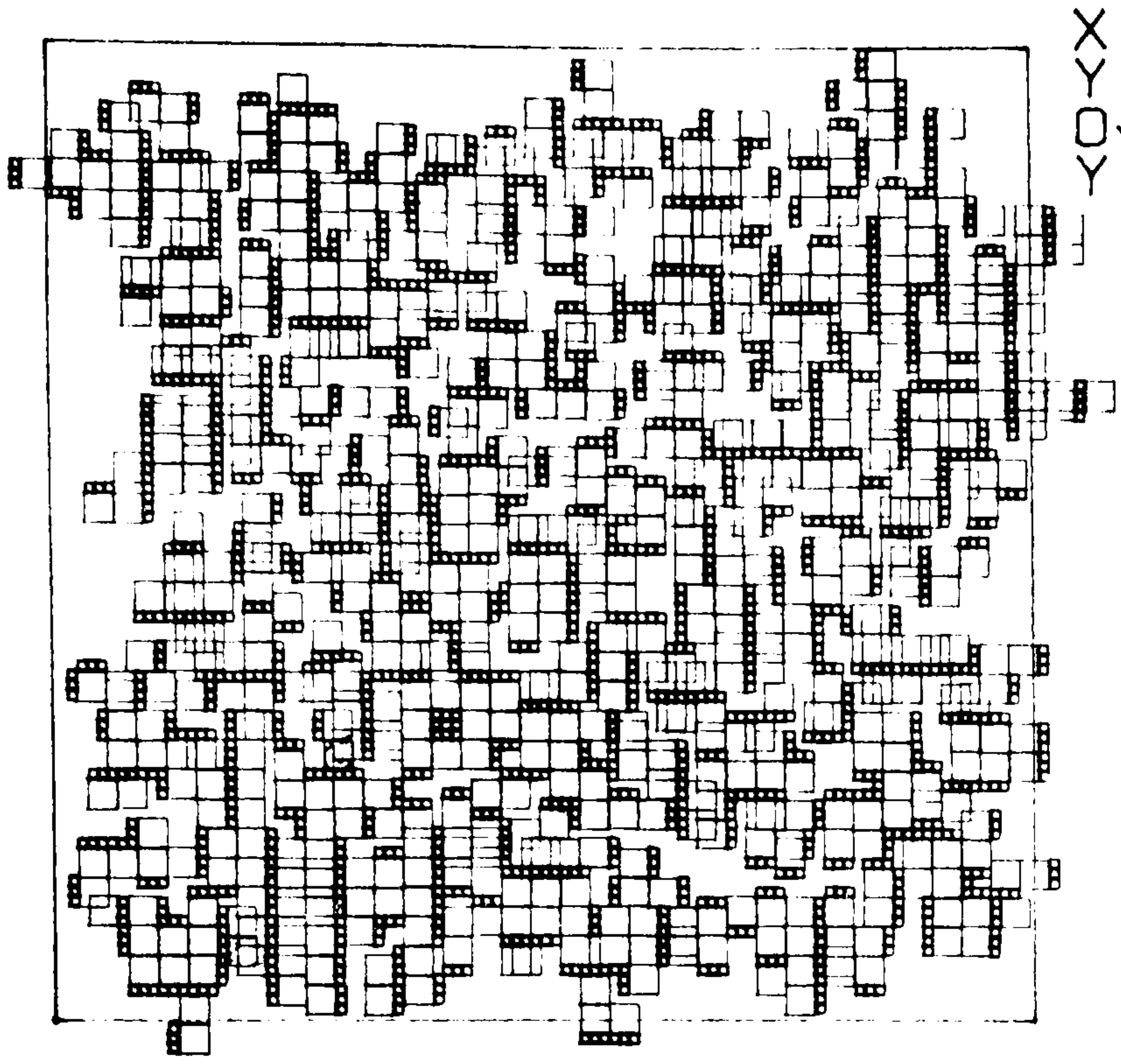


X clustering 0.80
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.80

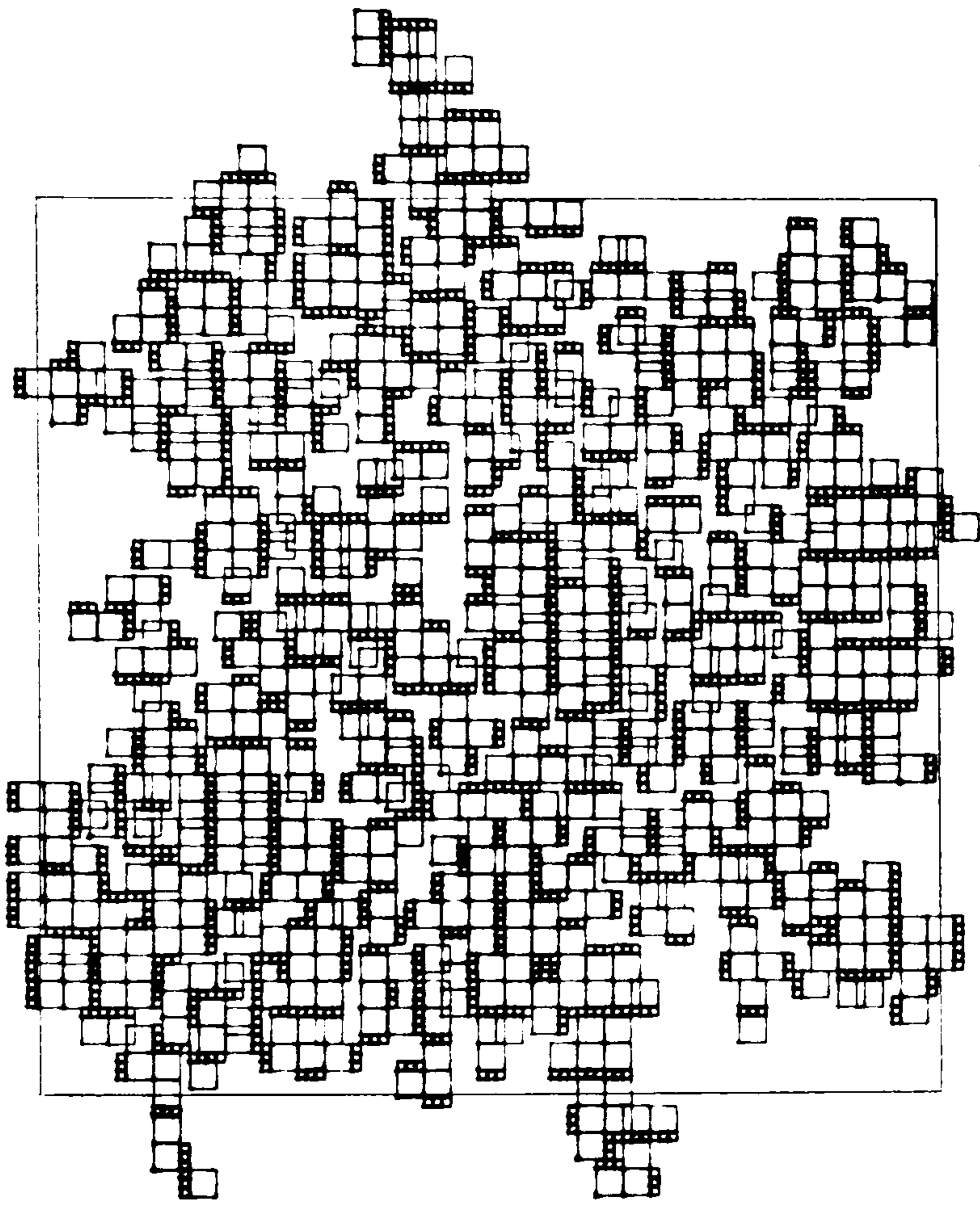




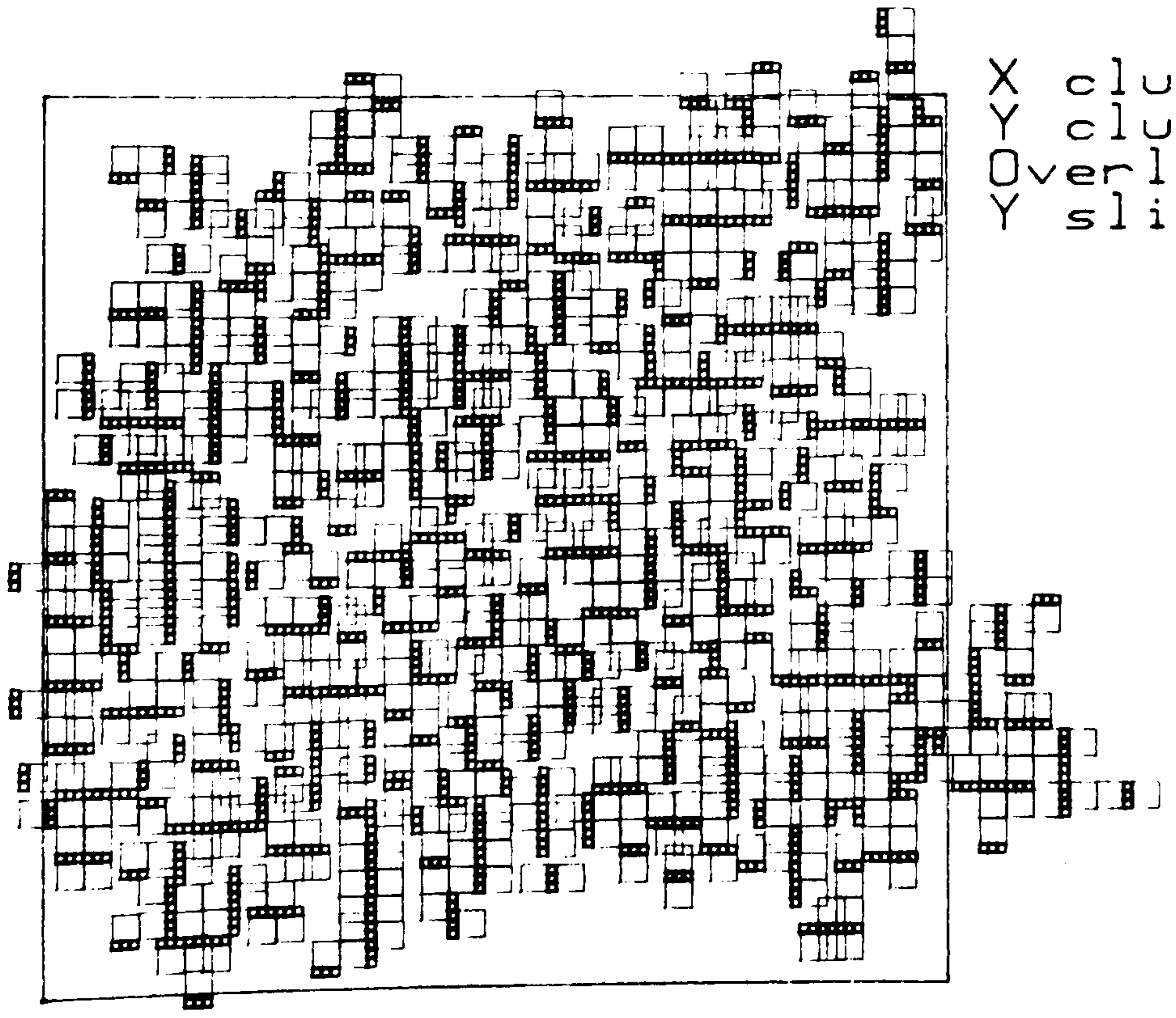
X clustering 0.80
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.80



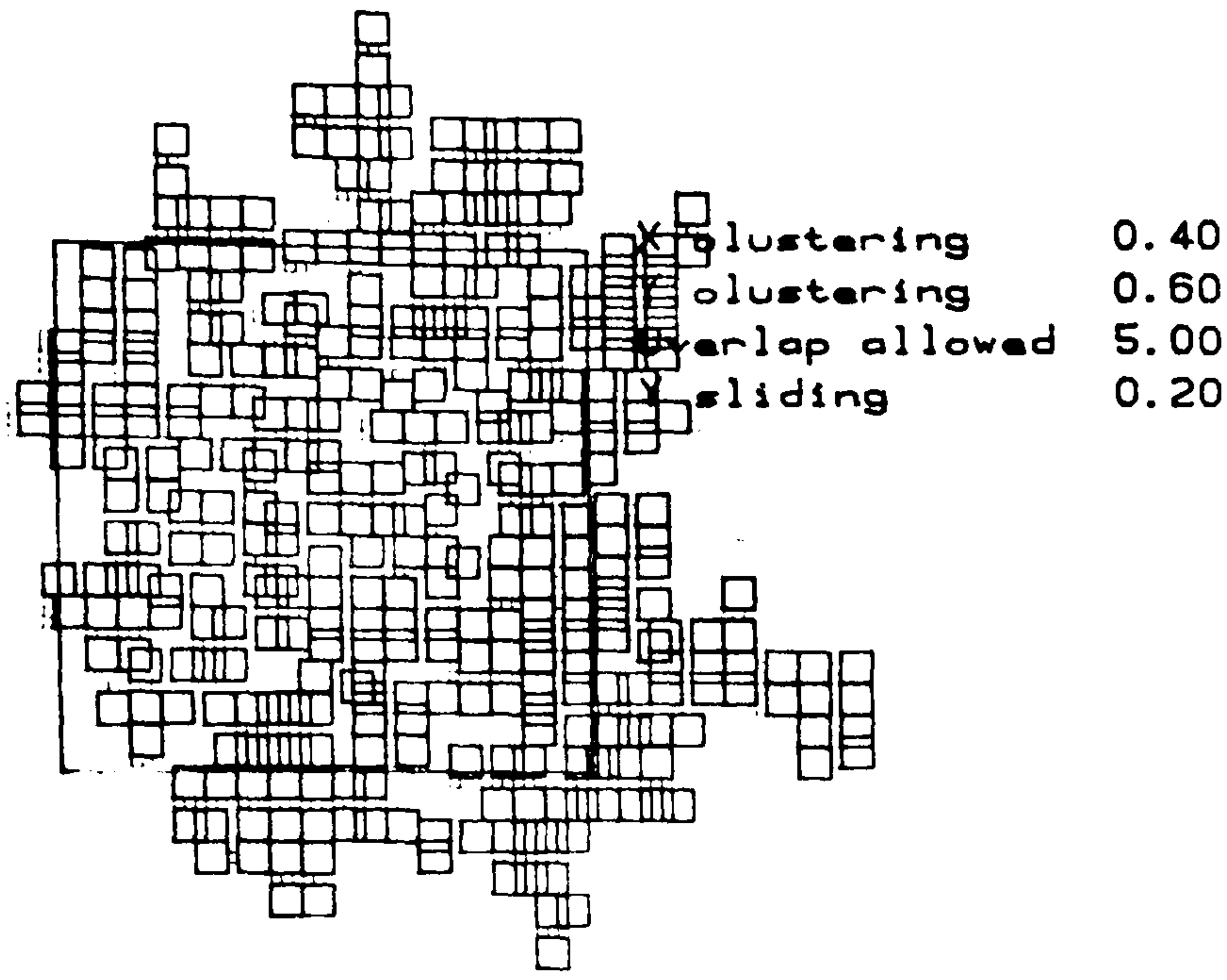
X clustering 0.60
Y clustering 0.40
Overlap allowed 6.00
Y sliding 0.80

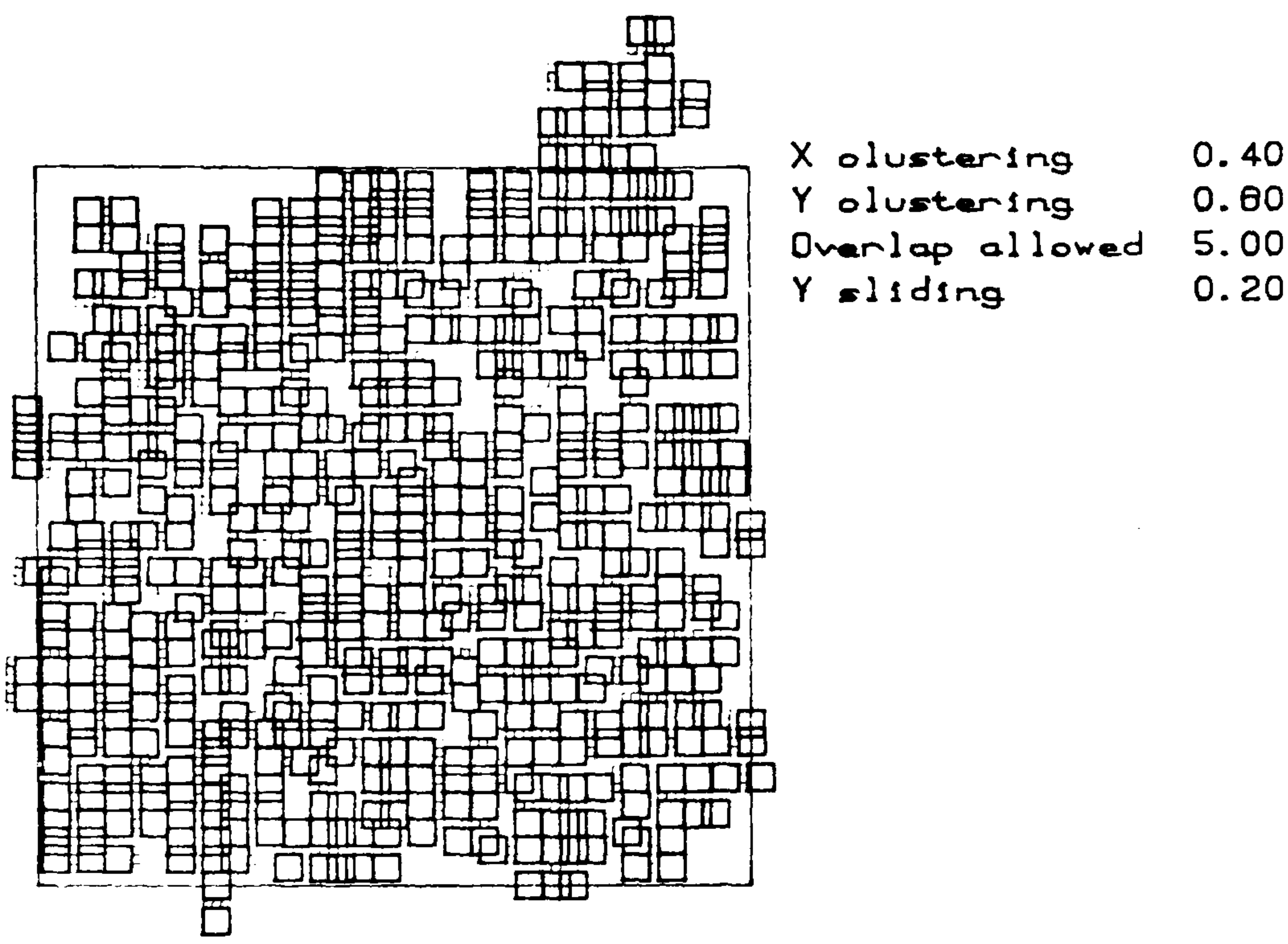


X clustering 0.60
Y clustering 0.40
Overlap allowed 5.00
Y sliding 0.80



X clustering 0.50
Y clustering 0.50
Overlap allowed 5.00
Y sliding 0.50


X clustering 0.40
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.20


X clustering 0.40
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.20

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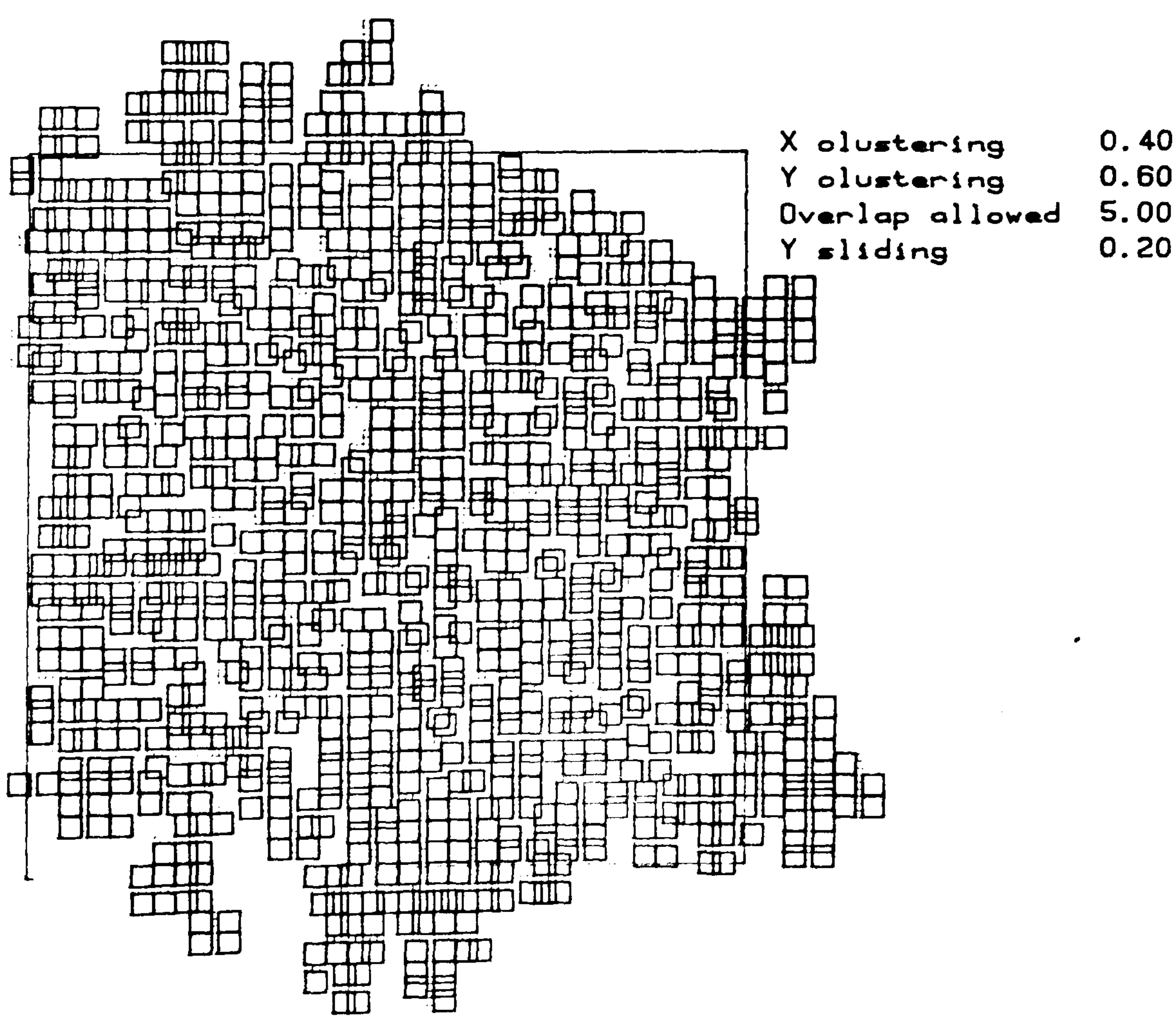
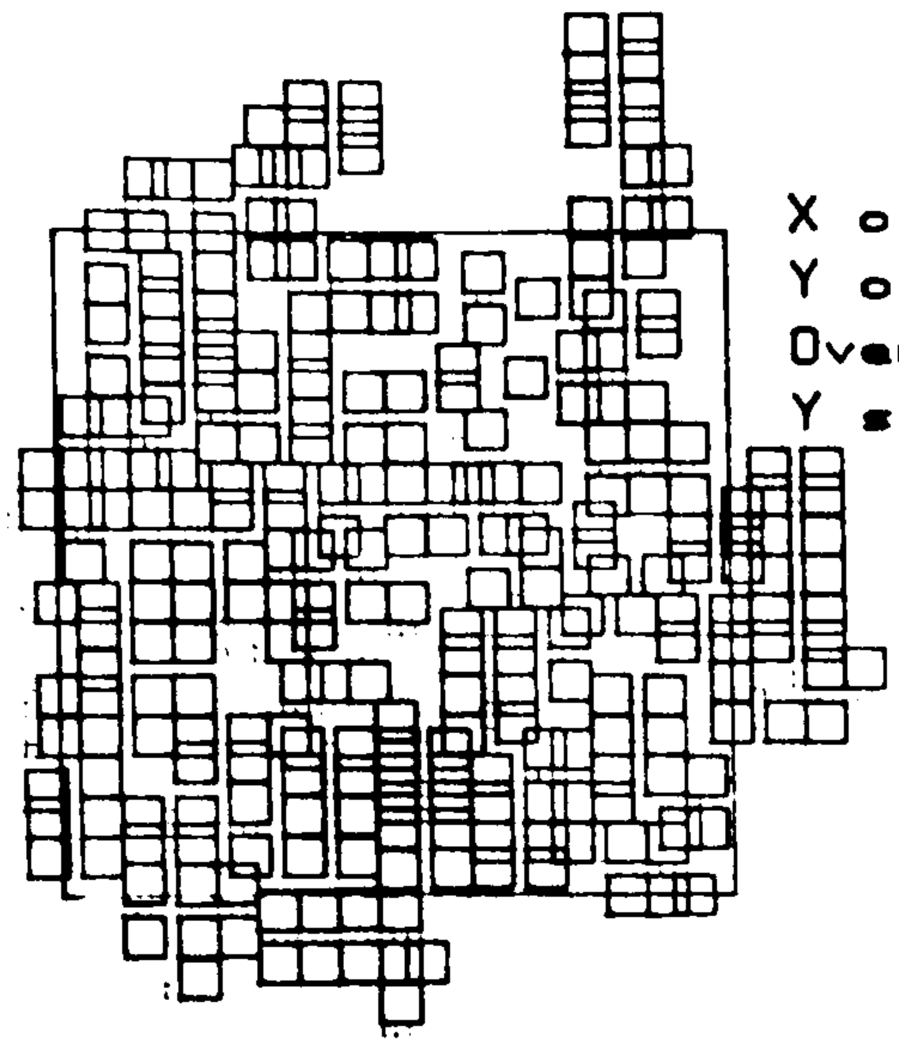
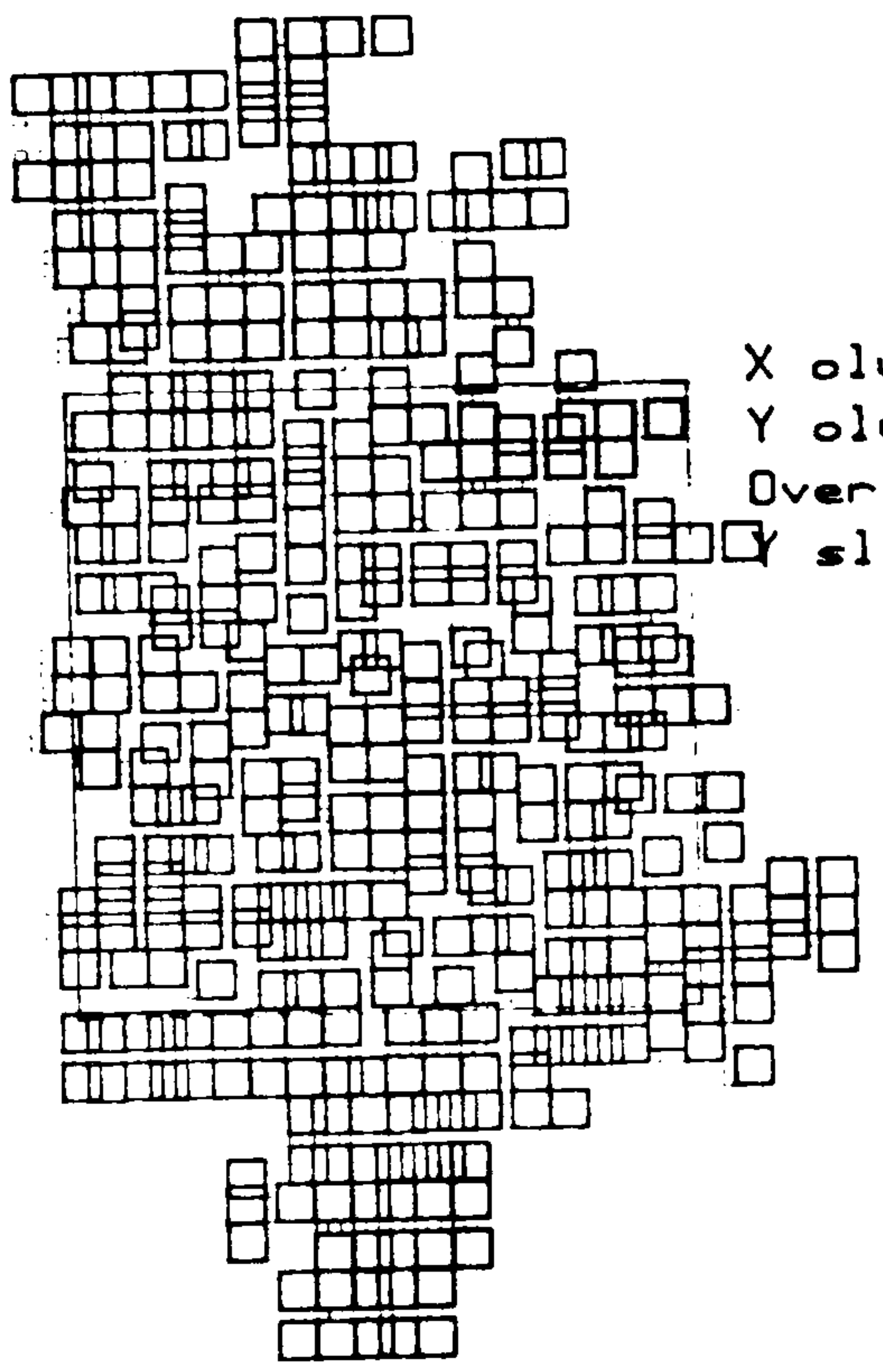
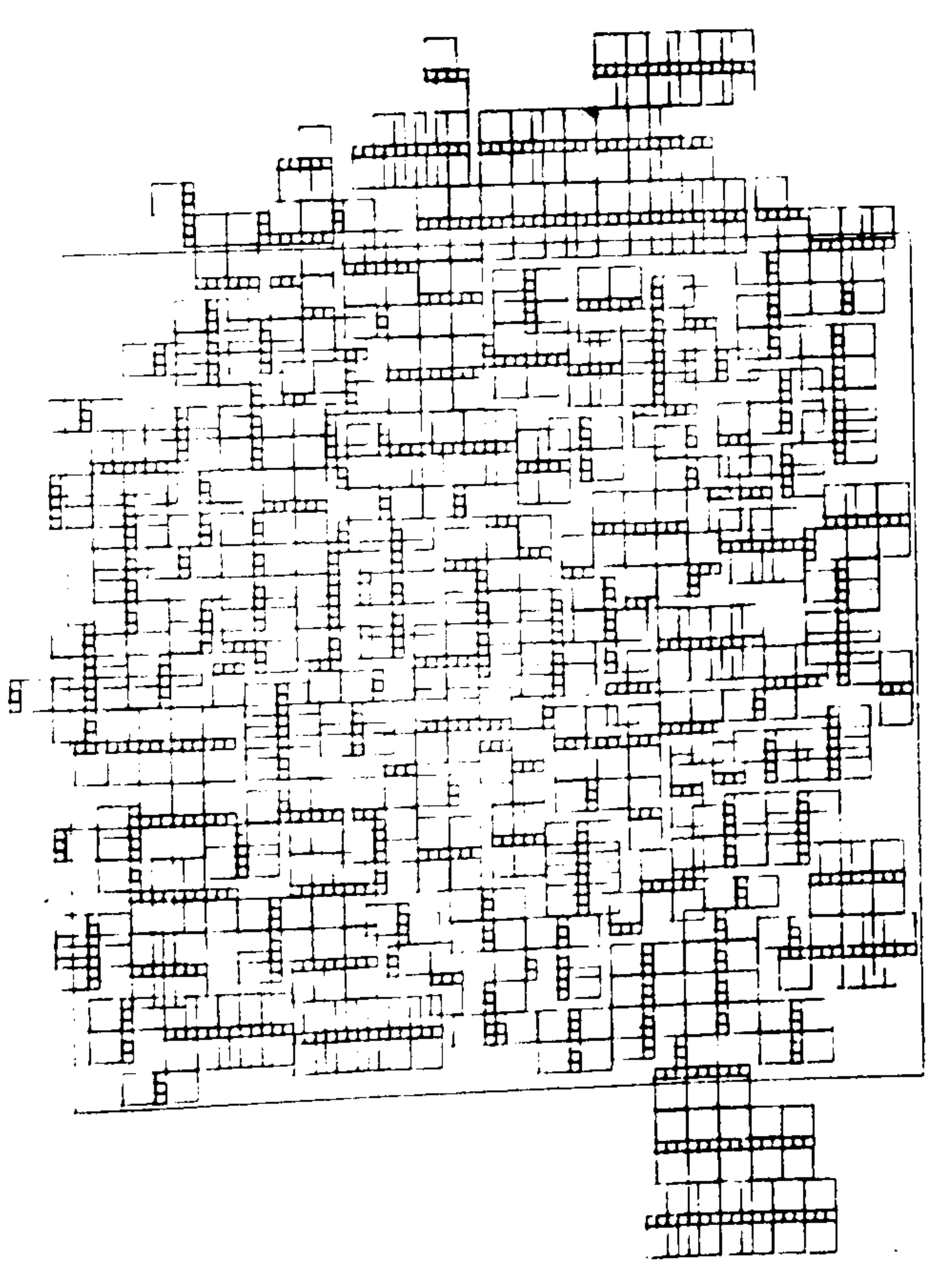

X clustering 0.40
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.20



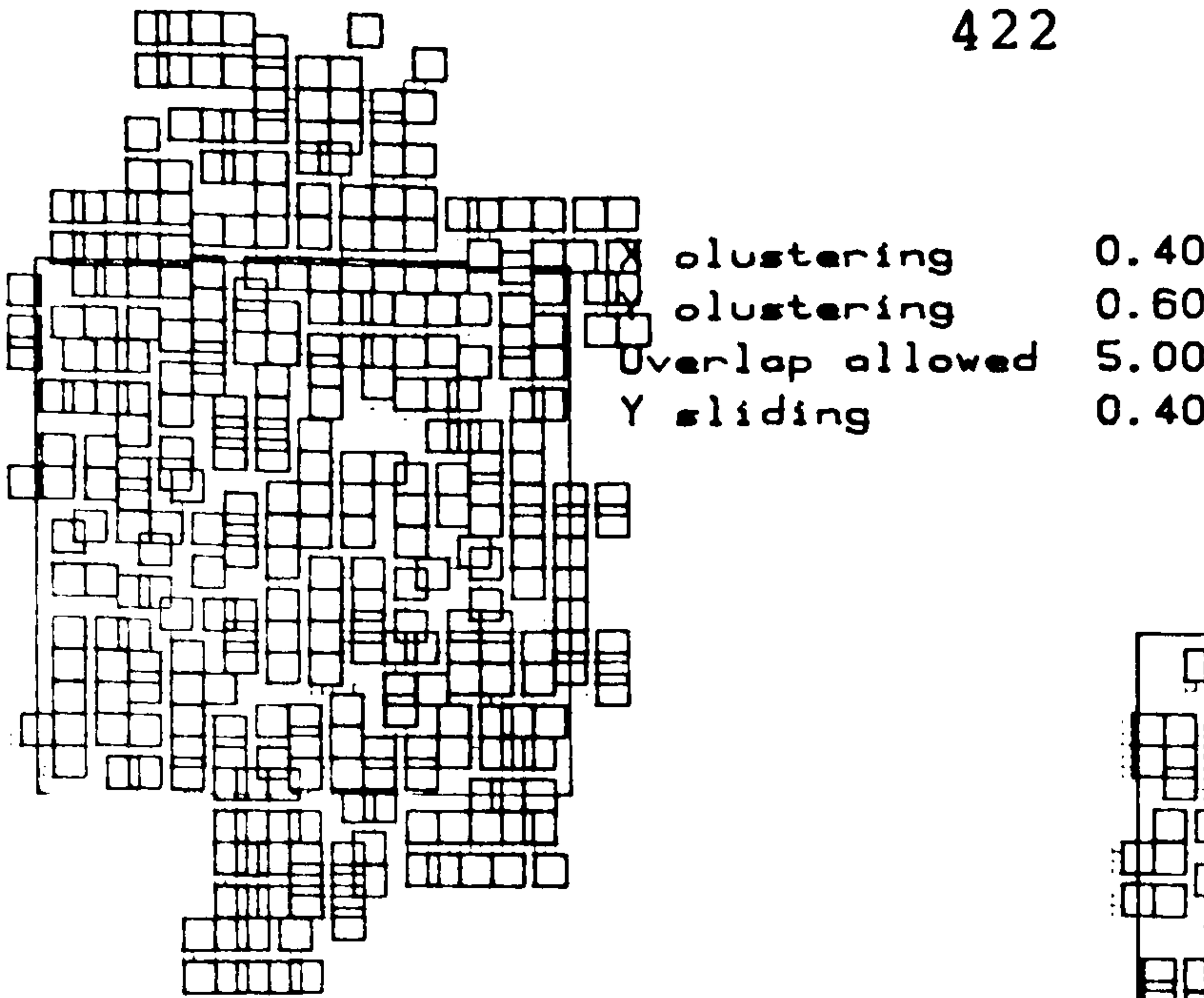
X clustering 0.40
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.20

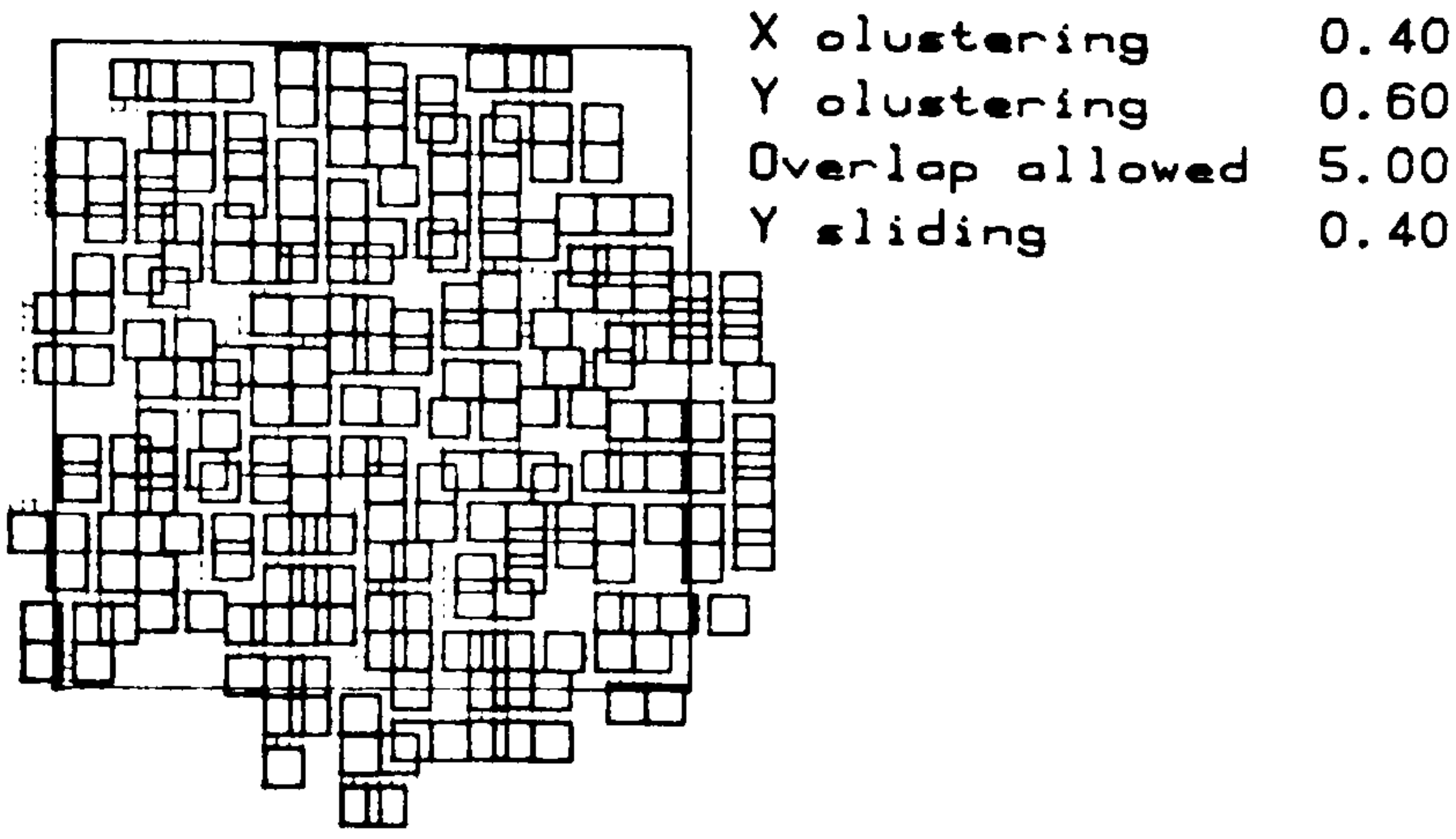


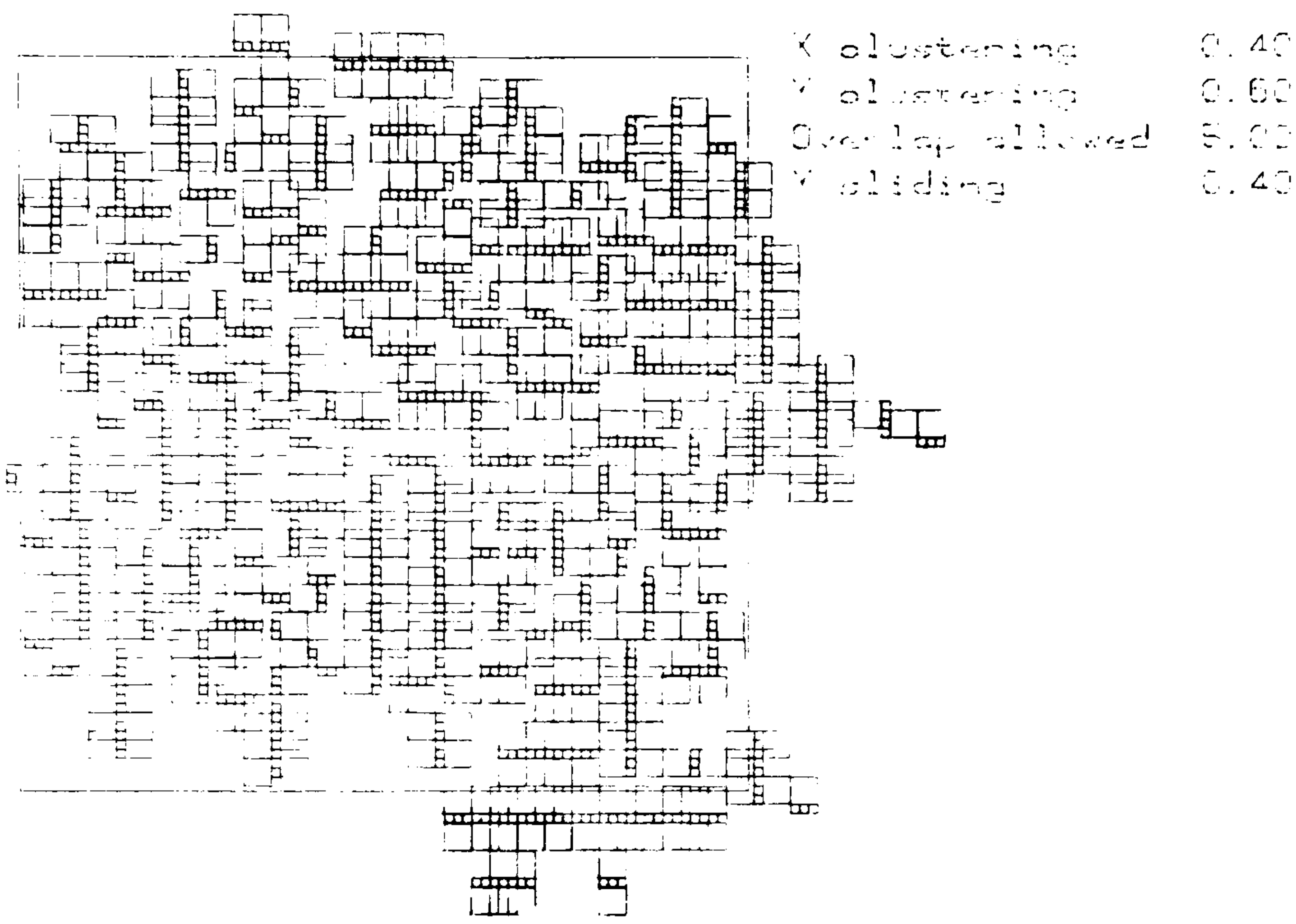
X clustering 0.40
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.20

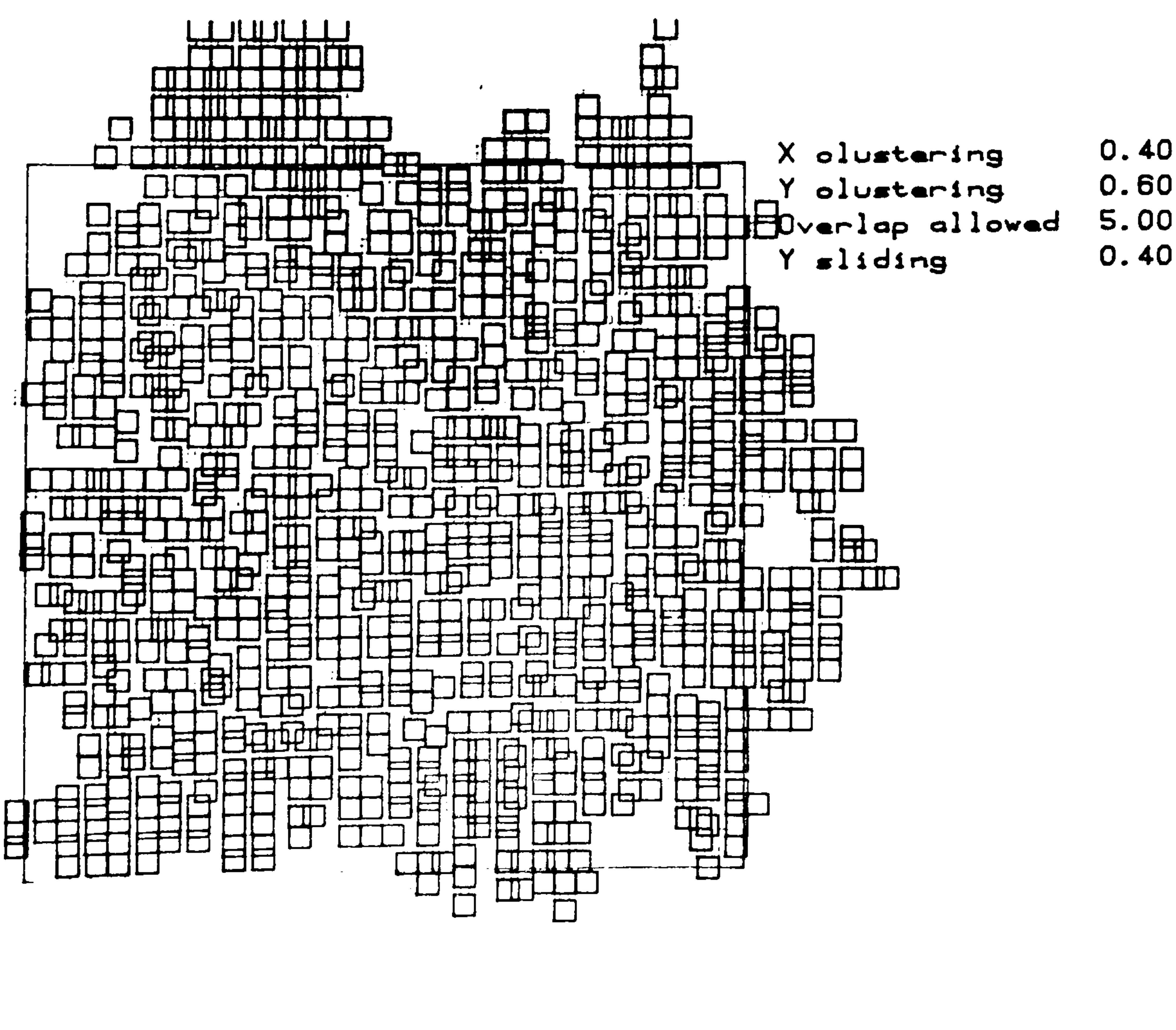


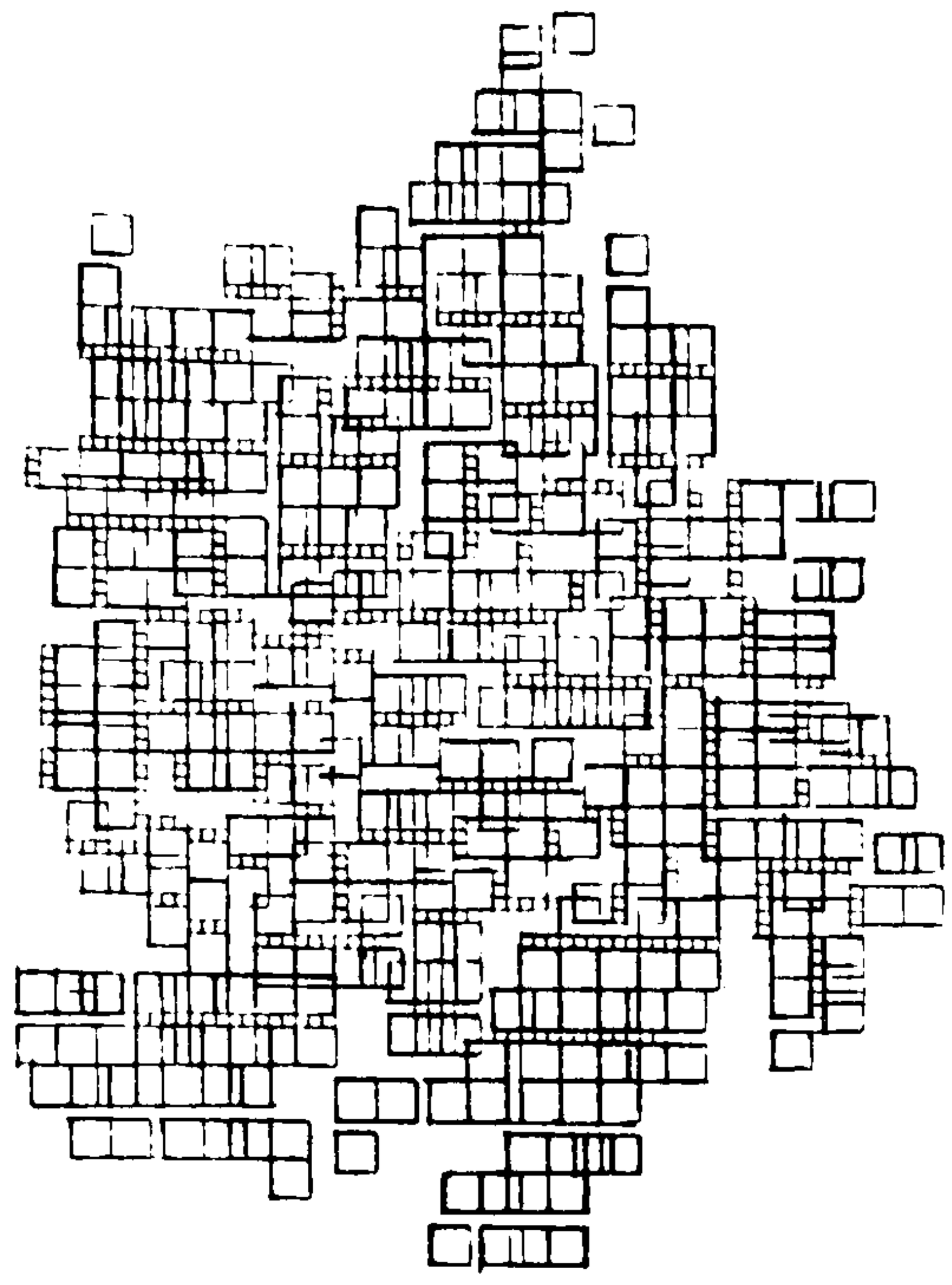
X clustering 0.40
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.20

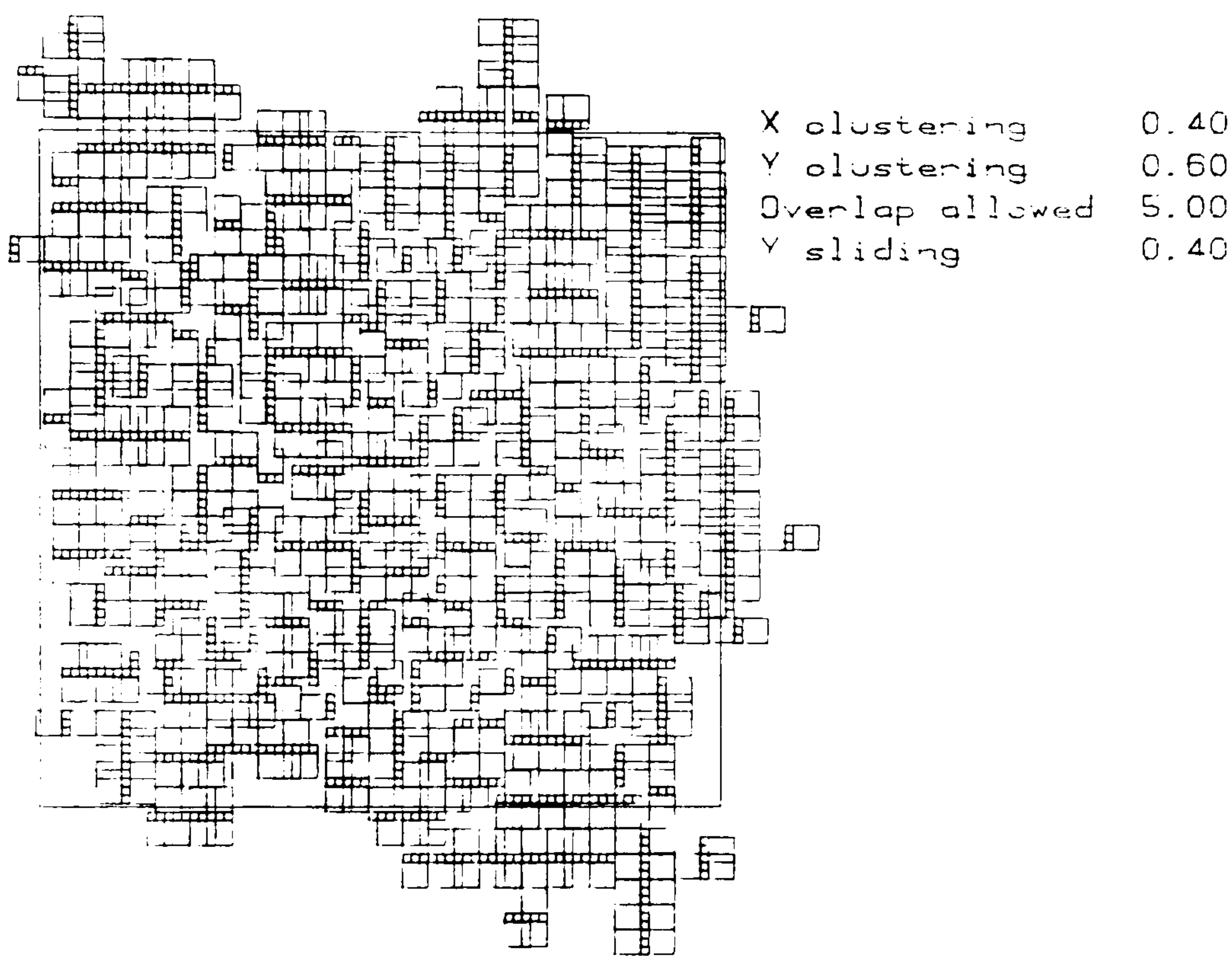

X clustering 0.40
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.40

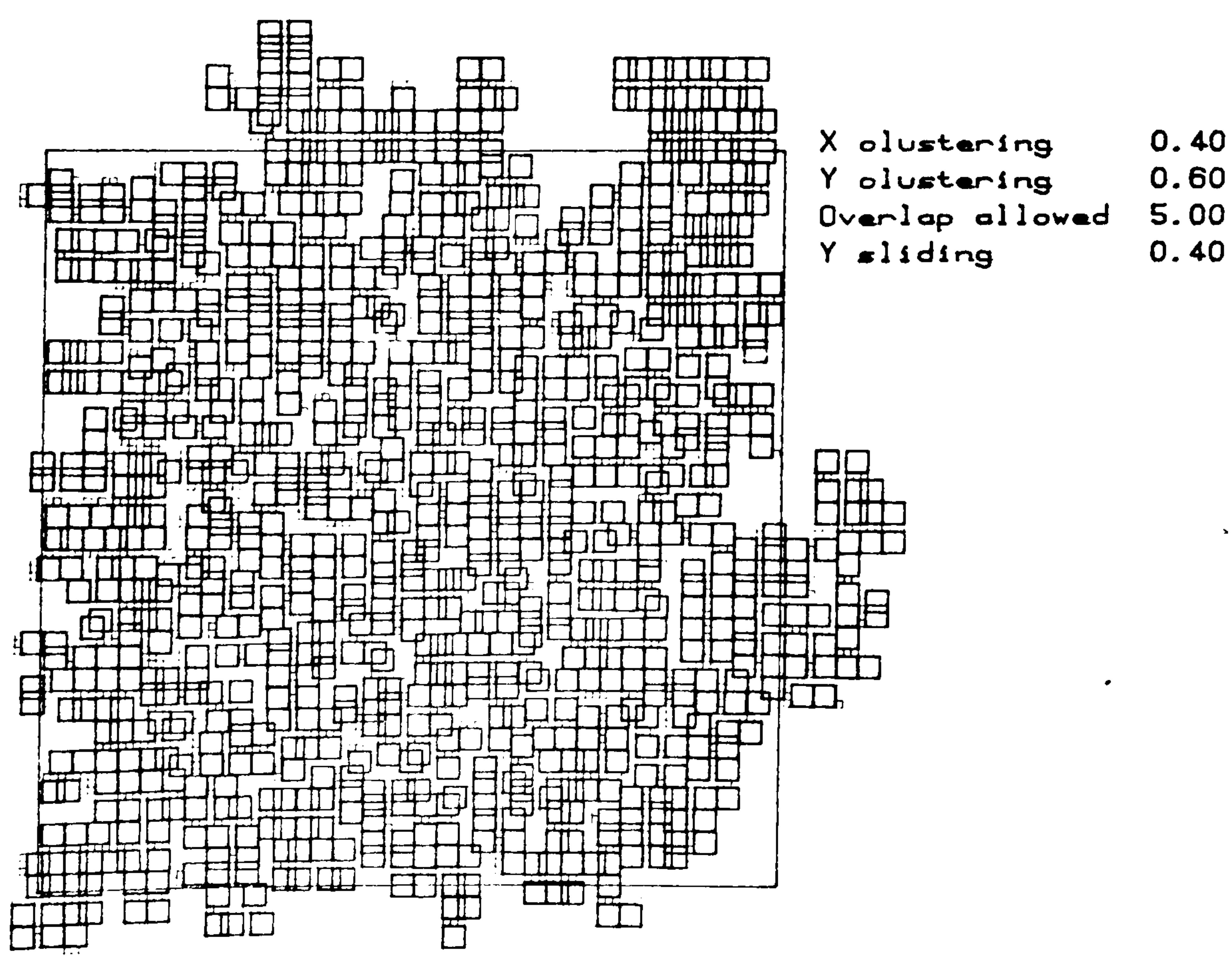

X clustering 0.40
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.40

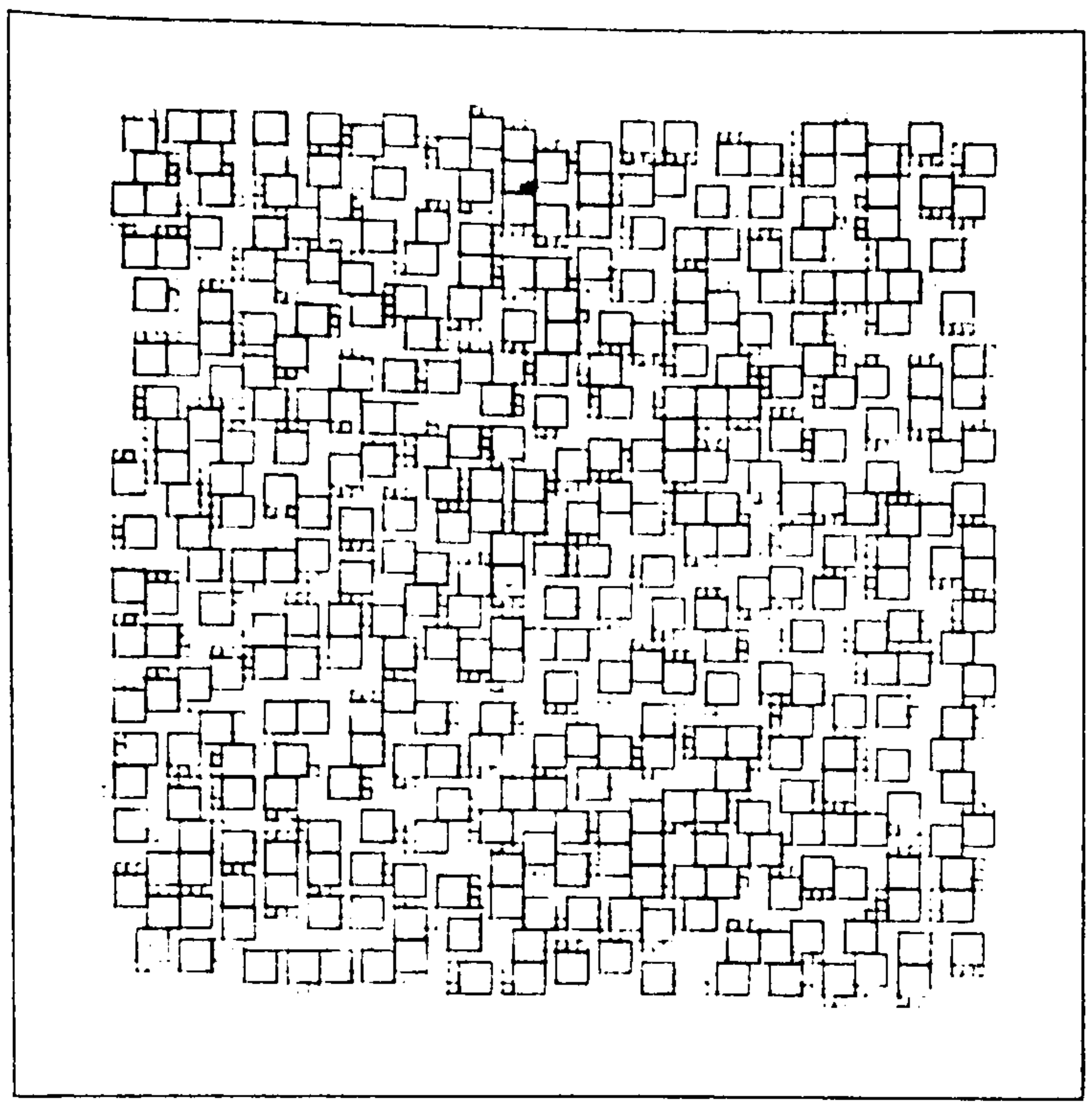

X clustering 0.40
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.40


X clustering 0.40
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.40

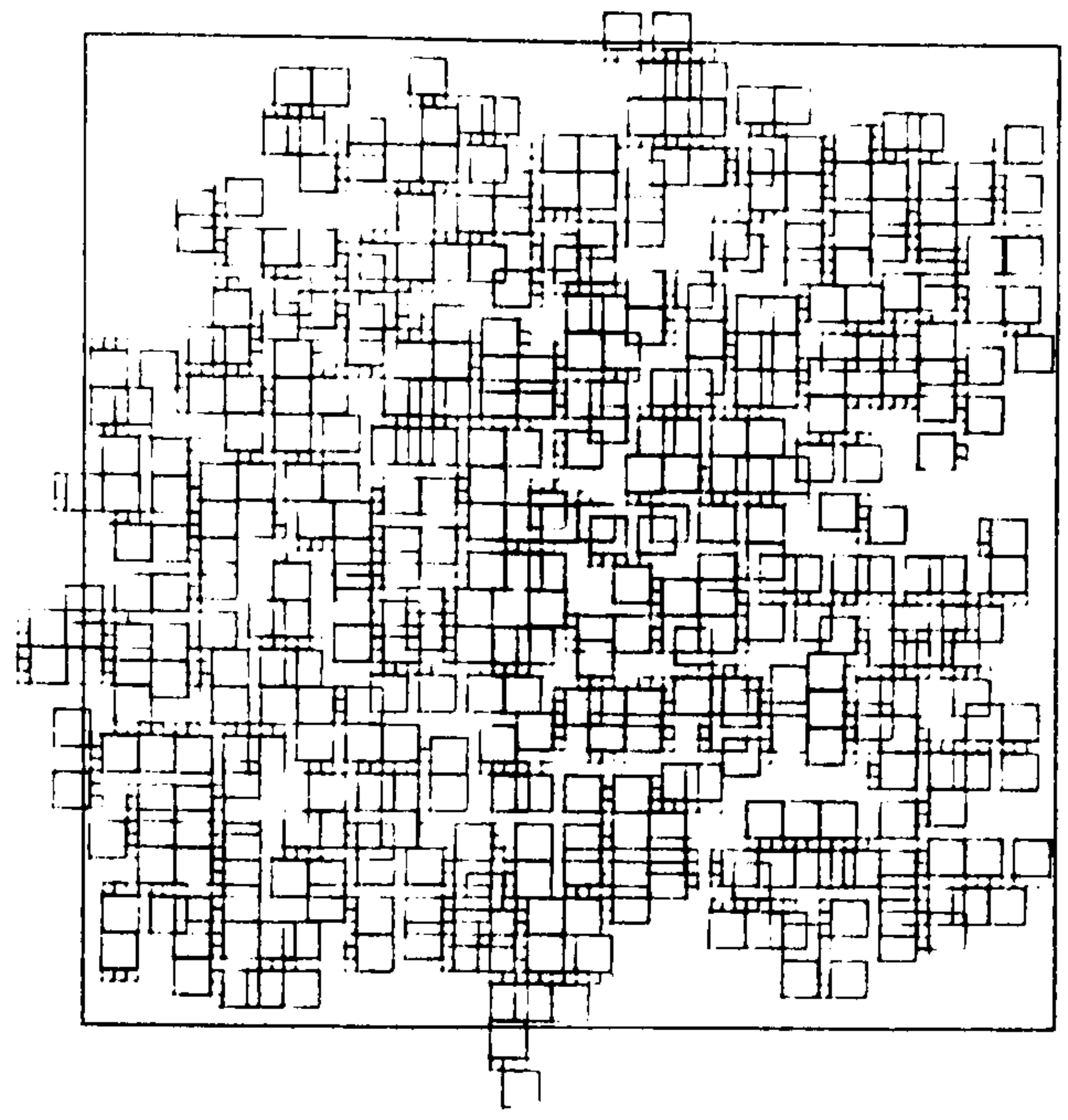



X clustering 0.40
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.40

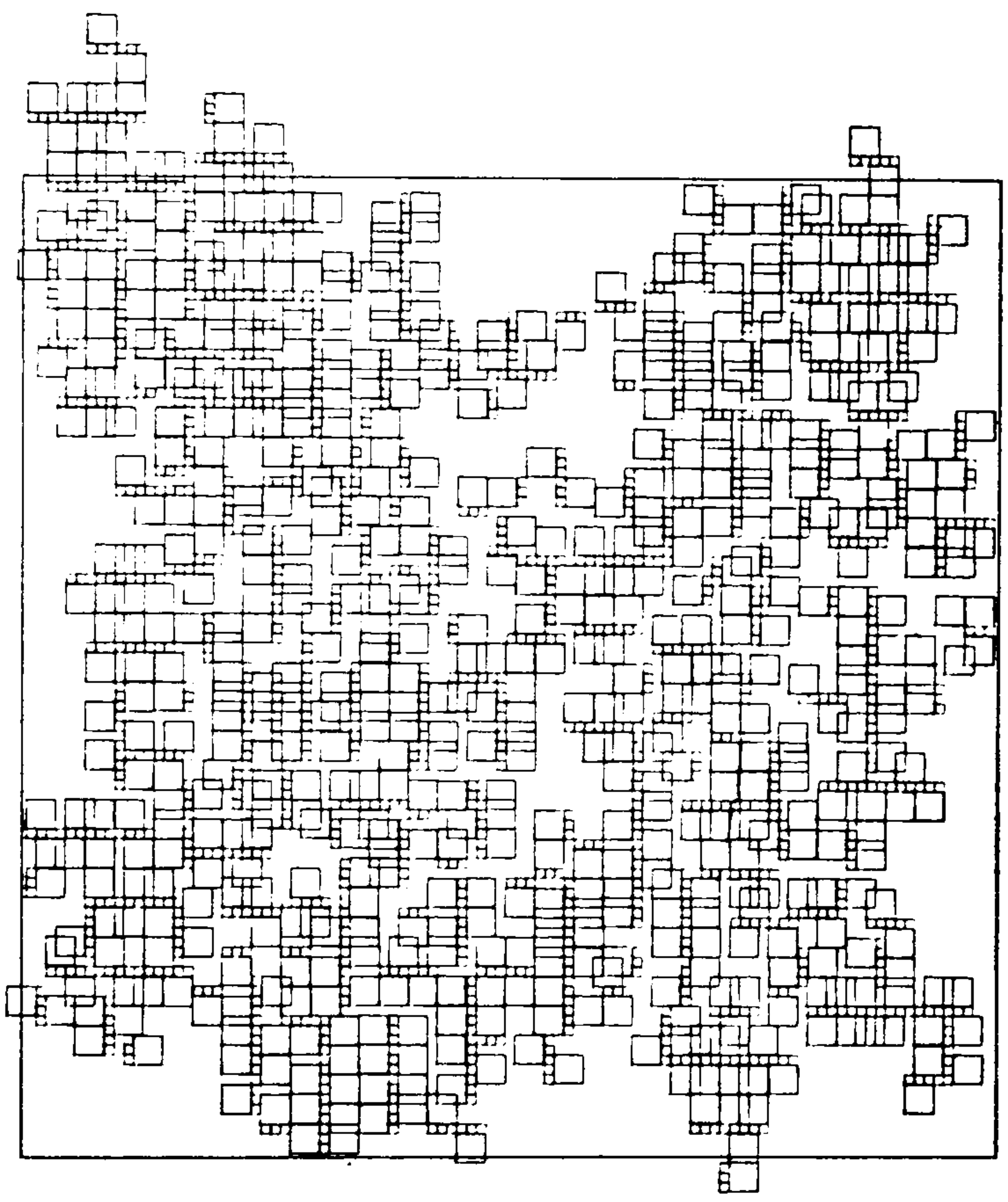

X clustering 0.40
Y clustering 0.60
Overlap allowed 5.00
Y sliding 0.40



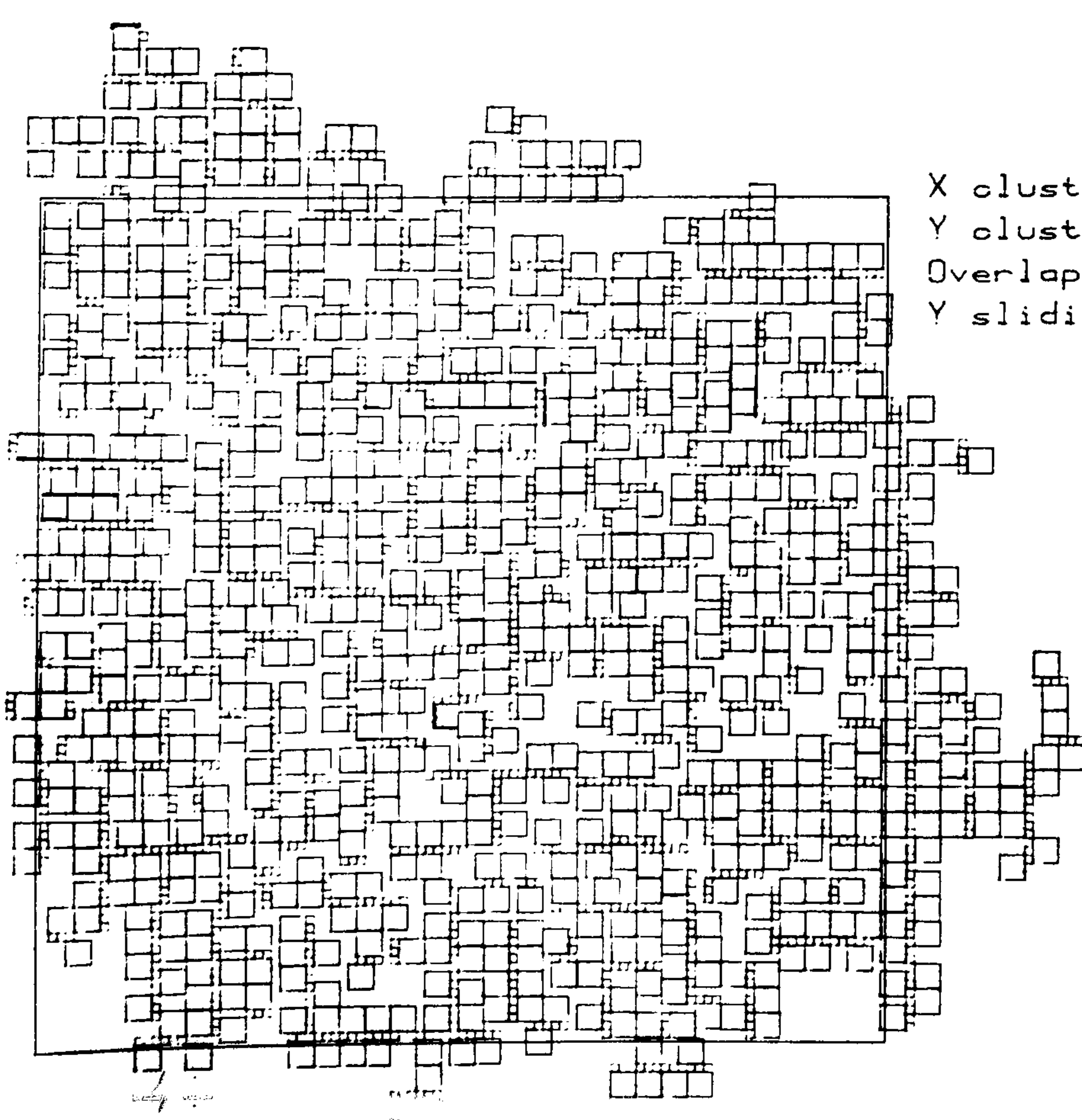
X clustering 0.00
Y clustering 0.00
Overlap allowed 0.00
Y sliding 0.00



X clustering
Y clustering
Overlap allowed
Y sliding



X clustering 0.40
Y clustering 0.60
Overlap allowed 5.00
Y sliding 1.00



X clustering 0.40
Y clustering 0.60
Overlap allowed 0.00
Y sliding 0.80